Robson Seed Farms

... great extent upon producing vegetables above the average in appearance and quality.

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The Vegetable Growing Business

by Ralph L. Watts
and
Gilbert Searle Watts

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INTRODUCTION

In the preparation of this volume the authors have endeavored to include subject-matter necessary for a general text in vegetable growing and also information which should be helpful to commercial growers who desire a handy reference book.

The treatise devotes equal attention to principles and practice, to the science and to the art of growing and marketing vegetables. Special effort has been made to place adequate emphasis on the importance of the economic and the executive or managerial phases of the business for successful and profitable operation under highly competitive conditions.

The literature of the vegetable growing field has been consulted freely and acknowledgment is made of help from many such sources. For brevity, statements have been made without supporting data or references, conforming as nearly as possible to the generally accepted views of research workers and experienced growers. A topical list of references is included in the Appendix.

The practical experience of the authors as commercial vegetable growers and their observations as well as their studies of operations on many outstanding vegetable farms are reflected in the text.

The authors are indebted especially to Dr. Warren B. Mack of the Department of Horticulture of The Pennsylvania State College and Dr. Paul Work of the Department of Vegetable Crops of Cornell University for reading the manuscript and making many important suggestions, and to Dr. James W. Sinden of the Department of Botany of The Pennsylvania State College for writing the material relating to mushrooms.

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Ralph L. Watts,
Gilbert S. Watts.

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I

GENERAL VIEW

VEGETABLE growing, including the several classifications, is among the most important sources of farm income. In recent years the value of vegetables * has ranked about equal with the gross income from cotton or the leading grains, such as corn or wheat, and one-half more than the returns from fruits and nuts; that is, about a billion dollars a year—approximately one-fourth of the crop dollars of the country or one-tenth of all agricultural income. The total acreage of vegetables is about 10,000,000 with an estimated average income of about $100 an acre. Vegetable growing finds a place with nearly every tiller of the soil. The home garden, with perhaps a surplus of produce for sale, is of great economic importance and represents about one-fourth of the total for vegetables. Acreage of vegetable crops for market, canning, and manufacture has almost trebled within 20 years, yet price trends have followed closely the average of 30 basic commodities, indicating vast increase in demand.†

Market gardening, in the generally accepted meaning, is the intensive culture of crops that may be planted close together, that mature quickly, and that offer large income from the area cultivated. Market gardens are generally located near local markets. The land is usually of high value, the acreage is often small, and it is necessary for the grower to secure maximum returns for every square foot of ground. Ordinarily the market gardener plans to have continuous supply of a great variety of vegetables over as long a season as possible. He usually practices succession cropping and often intercropping. The income from market garden crops, for the country as a whole, is generally about one-third or more of the value of truck crops for market.

Truck farming.—There is no sharp line of demarcation between market gardening and truck farming. Both often are found on the same farm and the practices blend. In common usage truck farming means the production of vegetables on an extensive scale for more or less distant shipment. As a rule there is specialization in one crop or a few crops for the growing and timely marketing of which the soil and climate are especially favorable. The operations may be

* The term *vegetable* is applied to the edible parts of herbaceous plants. Some vegetables, such as watermelon and tomato, are botanically considered as fruits. Vegetable growing or the production of vegetable crops sometimes is referred to as olericulture.

†Statistics of acreages, yields, production, prices, and income are found in the Appendix.

near enough to good markets so that the products may be trans-ported by truck, or they may be removed hundreds or thousands of miles. Transportation facilities are of far-reaching importance in the development of truck farming regions. Generally the investment to the acre is much lower than in market gardening, and implements of large capacity are employed. There are important truck-farming districts in all the coast states and at many points in the interior.

Production for canning and manufacture.—High quality and low cost of canned vegetables, together with unequalled convenience in their storage and use, have advanced canning crop production to a position of great importance. Preservation by quick-freezing proc-esses has become an important factor in mass production and dis-tribution. Dehydration with improved methods is a promising development. There is increasing commercial interest in the process-ing of certain vegetables to extract starches, sugars, vitamins, essen-tial oils or other valuable constituents.

To meet competition the manufacturer must have vegetables o quality at low cost. In consequence the industry is scattered widely with extensive development where soil, climate, management, o other factors favor high yields, low cost, and superior quality. Vege-tables for manufacture generally are grown on contract betwee grower and processor and often are produced in rotation with gen-eral farm crops. In some localities production may be equally ex-tensive for manufacture and for market.

Vegetable forcing is the growing of vegetables out of season i greenhouses, hotbeds, and cold frames, and, in the case of a fe crops, in cellars, caves, or heated buildings. Forcing, the most in-tensive type of vegetable growing, often is combined with marke gardening as the glass is of great advantage in starting certain earl crops and in providing work during winter months.

Home vegetable gardening is an intensive type of gardenin which is of greater importance than we generally appreciate. Amp and varied supplies of fresh, high quality vegetables may be pr duced continuously in season. Economies may be effected in th food budget, and a more appetizing, health-assuring diet can be pr vided. The garden merits and rewards adequate care. The su plus from home gardens often becomes an important factor in t markets of smaller cities.

Vegetable seed production.—Commercial seed growing is vast, specialized and highly technical branch of the vegetable indu try. Greatest development has been attained in the West whe conditions are favorable for curing and relatively disease free see especially of peas and beans, can be produced. Home or small-sca seed growing of some crops is fairly common.

Capital required.—The capital required to the acre to equ

and operate a vegetable growing business depends upon several factors: (1) The size of the farm. Small places require relatively more capital than larger ones. (2) The amount of glass and irrigation. (3) The type of production. Market gardening requires much more capital to the acre than truck farming, and diversified truck farming requires more capital than special farming, such as the growing of celery, onions, tomatoes, or cabbage. The more intensive the business, the greater the capital needed. (4) The fertility of the land. Impoverished land requires heavy expenditures for manure and fertilizers to secure satisfactory crops.

In addition to the cost of land, large expenditures are required for motor equipment or horses, implements, sprayers, tools, fertilizers, labor, and packages. Insufficient working capital is a serious and dangerous handicap. It may be better to make a modest beginning than to borrow heavily with the inevitable uncertainties of production and marketing.

A typical investment would be approximately \$200 or \$250 to the acre for a well-equipped place of 30 to 100 acres when operations are divided between market gardening and truck farming. Twice that investment or more is common among the more intensive vegetable farms where much irrigation equipment and glass are included. An investment of \$50 to the acre, or less for a renter, may be sufficient for operations with one crop or a few crops on low-priced land. Use of capital is considered on page 66.

Outlook.—Use of vegetables is increasing. There is more general appreciation of the benefits to be derived from variety and abundance of vegetables in the diet. Unusually satisfying quality, that is, genuine goodness, in a larger proportion of all vegetables sold will continue to increase their use. The acreage of vegetables has expanded, over a term of years, about as rapidly as the demand. Adjustments are quick and prices tend to range close to average cost of production. Profit is difficult unless circumstances are favorable for production and marketing, and management is of the best.

A definite trend is the decline of market gardening and the rise, in relative importance, of truck farming. Displacement of horses by motor vehicles has nearly eliminated the supply of manure once available for intensive gardening. Cities have overgrown much of the best land in their close proximity. Meanwhile, improvements in transportation, refrigeration, and merchandising have placed, in every city and crossroads store, reasonably priced, attractive vegetables from near and distant farms.

It is clearly evident that the vegetable grower must compete with rising standards of appearance, quality, grading, and packing. Excellent canned and frozen products compete with fresh vegetables, and those of certain individuals, groups, or districts compete

with similar offerings of others. The search for markets proceeds in every direction, and overlaps, by personal contacts, by wire, and by trial shipments. Very often sales at a profit may be made only by exceptionally economical production, by offering products that are above average in appearance and quality, or through unusual dependability of pack and continuous supply.

Opportunities continue to exist, however, not only for the established growers but for the newcomers who shrewdly choose their undertakings. Perhaps one will succeed with conventional market garden methods and intimate market contacts, such as roadside selling or direct delivery to homes or stores. He will profit from the demand for farm-freshness, particularly with vegetables that lose quality rapidly. Another probably can produce exceptionally well-formed and bright root crops, or some other crop or crops of more than average perfection, at an earlier or later date, or at lower cost. Such advantage often offsets the disadvantage of great distance to market. Others succeed by doing a particularly good job of grading, packing, and marketing. Many dairy farmers, fruit growers, and poultrymen increase their income by growing vegetables. Perhaps conditions are not entirely favorable for the enterprise and yet it may fit into the farm business in a profitable manner. Under many conditions a modest start should be made, followed by larger plantings from year to year if returns justify.

CLASSIFICATION OF VEGETABLES

Botanical classification.—Grouping of vegetables gives better understanding of the relationships, requirements, and uses of the various crops. The arrangement based on botanical relationship, that is relationship by descent as indicated by floral characteristics, is of advantage for exact identification in plant breeding, and in considering the control of insects and diseases which may attack the several vegetables and weed species within a family or a genus of plants. The botanical classification is also of value, to a limited extent, in considering the cultural requirements for each crop. The following classification is from Bailey's "Manual of Cultivated Plants."

Botanical List of the Vegetable Crops Giving Family, Generic and Specific Names.

Monocotyledonæ		
Gramineæ—Grass Family		
Zea Mays	var. rugosa	Sweet corn
Liliaceæ—Lily Family		
Allium sativum		Garlic
Allium Porrum		Leek

BOTANICAL LIST OF THE VEGETABLE CROPS GIVING FAMILY, GENERIC AND SPECIFIC NAMES.—(*Continued.*)

Allium fistulosum		Welsh onion
Allium ascalonicum		Shallot
Allium Schoenoprasum		Chive
Allium Cepa		Onion
Allium Cepa	var. solaninum	Potato onion
Allium Cepa	var. viviparum	Top onion
Asparagus officinalis		Asparagus
Dicotyledoneæ		
Polygonaceæ—Buckwheat or Knotweed Family		
Rheum Rhaponticum		Rhubarb
Rumex Acetosa		Garden sorrel
Rumex Patientia		Spinach dock
Chenopodiaceæ—Goosefoot Family		
Beta vulgaris		Beet
Beta vulgaris	var. Cicla	Swiss chard
Atriplex hortensis		Orach
Spinacia oleracea		Prickly-seeded spinach
Spinacia oleracea	var. inermis	Round-seeded spinach
Aizoaceæ—Carpet-weed Family		
Tetragonia expansa		New Zealand spinach
Cruciferæ—Mustard Family		
Brassica oleracea	var. acephala	Kale, borecole
Brassica oleracea	var. gemmifera	Brussels sprouts
Brassica oleracea	var. capitata	Cabbage
Brassica oleracea	var. botrytis	Cauliflower, broccoli
Brassica oleracea	var. italica	Asparagus or sprouting broccoli
Brassica caulorapa		Kohlrabi
Brassica Napobrassica		Rutabaga
Brassica Rapa		Turnip
Brassica juncea		Leaf mustard
Brassica juncea	var. crispifolia	Southern curled mustard
Brassica alba		White mustard
Brassica pekinensis		Pe-tsai Chinese cabbage
Dicotyledoneæ		
Brassica chinensis		Pak-choi Chinese cabbage
Barbarea vulgaris		Upland cress
Roripa Nasturtium aquaticum		Watercress
Armoracia rusticana		Horseradish
Lepidium sativum		Garden cress
Raphanus sativus		Radish
Crambe maritima		Sea kale
Leguminosæ—Pea or Pulse Family		
Pisum sativum	var. humile	Early dwarf pea
Pisum sativum	var. macrocarpon	Edible podded pea
Vicia Faba		Broad bean
Phaseolus vulgaris		Kidney bean
Phaseolus vulgaris	var. humilis	Bush bean

Botanical List of the Vegetable Crops Giving Family, Generic and Specific Names.—(*Continued.*)

Phaseolus coccineus		Multiflora or scarlet runner bean
Phaseolus coccineus	var. albus	White Dutch runner
Phaseolus lunatus		Sieva bean
Phaseolus limensis		Lima bean
Phaseolus limensis	var. limenanus	Bush lima bean
Vigna sesquipedalis		Asparagus or yard-long bean
Vigna sinensis		Cowpea
Glycine Max		Soy-bean
Malvaceæ—Mallow Family		
Hibiscus esculentus		Okra
Araliaceæ—Ginseng Family		
Aralia cordata		Udo
Umbelliferæ—Parsley Family		
Daucus Carota	var. sativa	Carrot
Fœniculum vulgare		Fennel
Petroselinum hortense		Parsley
Petroselinum hortense	var. radicosum	Turnip-rooted parsley
Apium graveolens	var. dulce	Celery
Apium graveolens	var. rapaceum	Celeriac
Pastinaca sativa		Parsnip
Anthriscus Cerefolium		Salad chervil
Convolvulaceæ—Morning Glory Family		
Ipomœa Batatas		Sweet potato
Solanaceæ—Nightshade Family		
Solanum tuberosum		Potato
Solanum Melongena	var. esculentum	Eggplant
Lycopersicon esculentum	var. commune	Common tomato
Physalis pubescens		Husk tomato
Capsicum frutescens	var. grossum	Bell or sweet pepper
Martyniaceæ—Martynia Family		
Proboscidea louisiana		Martynia
Valerianaceæ—Valerian Family		
Valerianella Locusta	var. olitoria	Corn salad
Cucurbitaceæ—Gourd Family		
Cucurbita Pepo		Field pumpkin
Cucurbita Pepo	var. Melopepo	Bush pumpkin
Cucurbita moschata		Cushaw and win[ter] crookneck pumpkin
Cucurbita maxima		Winter squash
Citrullus vulgaris		Watermelon
Cucumis Anguria		West India gherkin
Cucumis sativus		Cucumber
Cucumis Melo	var. reticulatus	Netted muskmelon
Cucumis Melo	var. inodorus	Winter or cassaba me[lon]
Sechium edule		Chayote
Compositæ—Composite Family		
Cichorium Intybus		Chicory
Cichorium Endivia		Endive
Scolymus hispanicus		Spanish oyster plant

Botanical List of the Vegetable Crops Giving Family, Generic and Specific Names.—(*Continued.*)

Scorzonera hispanica		Black salsify
Tragopogon porrifolius		Salsify
Taraxacum officinale		Dandelion
Lactuca sativa	var. crispa	Curled lettuce
Lactuca sativa	var. capitata	Head lettuce
Lactuca sativa	var. longifolia	Cos or romaine
Cynara Cardunculus		Cardoon
Cynara Scolymus		Artichoke
Helianthus tuberosus		Girasole or Jerusalem artichoke

Classification by hardiness.—In respect to hardiness there are two general groups of vegetables. The "hardy" crops are resistant to frost, many of them, in fact, will stand severe freezing and thrive at low temperature. The important hardy crops are asparagus, rhubarb, beet, broccoli, cabbage, cauliflower, carrot, celery, kale, leek, lettuce, onion, parsley, parsnip, pea, radish, rutabaga, salsify, spinach, and turnip. The "tender" crops usually are injured or killed by frost and require high temperatures for successful growth. The principal tender crops are bean, cucumber, eggplant, melon, pepper, pumpkin, squash, sweet corn, sweet potato, and tomato.

The division between tender and hardy crops is arbitrary. Celery, for example, is classed properly with hardy crops, while low temperatures of some duration may cause the plants to produce seed shoots instead of marketable growth. Snap beans are less tender than lima beans, and sweet corn is hardier than either. Potatoes may be described as half hardy; the seed pieces germinate well in cool weather and the plants withstand light frosts.

"Cool season" and "warm season" are expressions employed to designate in general the temperature requirements of various crops. Typical cool season crops are cauliflower, pea, lettuce, and spinach. Typical warm season crops are eggplant, melon, tomato, and sweet potato.

Crops vary also in their responses to the length of day; spinach and radish, for example, go to seed slowly when days are short, rapidly when days are very long, especially with high temperature. Different varieties of the same vegetable exhibit marked variations in this respect, a characteristic of vital import in establishing seasonal and latitudinal adaptations. The relationship of the photoperiod to varietal adaptations of onions is especially notable.

Common classification.—The grouping which provides the best basis for discussion of cultural requirements is based primarily on methods of culture. Some of the divisions, however, are made according to botanical relationship, use, or convenience. The sequence

of chapters follows the approximate order of first sowings or plantings of important crops in the several groups.

Group 1.—Perennial Vegetables . . . . Asparagus, Rhubarb, Artichoke.	Chapter XIX
Group 2.—Greens . . . . Spinach, New Zealand Spinach, Dandelion, Mustard, Kale, Collards, Chard.	Chapter XVII
Group 3.—Cole Crops . . . . Cabbage, Cauliflower, Broccoli, Brussels Sprouts, Chinese Cabbage, Kohlrabi.	Chapter XIII
Group 4.—Salad Crops . . . . Celery, Lettuce, Parsley, Endive, Chicory, Cress, Corn Salad, Fennel.	Chapter XIV
Group 5.—Bulb Crops . . . . Onion, Leek, Garlic, Shallot, Welsh Onion, Chive.	Chapter XVI
Group 6.—Root Vegetables . . . . Beet, Carrot, Parsnip, Turnip, Rutabaga, Radish, Horse-radish, Celeriac, Salsify.	Chapter XVIII
Group 7.—Leguminous Vegetables . . . . Pea, Bean, Lima Bean.	Chapter XX
Group 8.—Potato Crops . . . . Potato, Sweet Potato.	Chapter XXI
Group 9.—Solanaceous Fruits . . . . Tomato, Pepper, Eggplant.	Chapter XV
Group 10.—Cucurbits . . . . Cucumber, Melon, Pumpkin, Squash.	Chapter XXIII
Group 11.—Sweet Corn	Chapter XXII
Group 12.—Okra, Martynia, and Herbs	Chapter XXIV

II

LOCATIONS AND SOILS

LOCATIONS

In selecting a farm for vegetable growing it is extremely important to secure a combination of circumstances that is favorable for profitable operation. Serious handicap may be incurred by overlooking or by neglecting to evaluate some factor. Circumstances of relative unimportance under some conditions may be of great consequence under others.

Markets.—A primary consideration in selecting a location or choosing crops is the opportunity to dispose of the produce in a satisfactory manner. Whether local markets, distant cities, or manufacturers are to provide the outlet, it is important to investigate the probability of advantageous sale.

In the large cities or other important centers of distribution tremendous volumes of produce can be moved rapidly, and a single sale or shipment may be large. The prospective grower should realize, however, that competition is keenest in the great markets and that prices are often very low. It is also true that such markets offer special inducements for growing strictly high-grade vegetables.

The smaller cities, as well as towns and summer resorts in many parts of the country, furnish important outlets for vegetables. Although many of these markets are less discriminating, high quality usually is appreciated and helps secure remunerative prices. The grower who is near a good market, whether it is large or small, can keep in close touch with his customers and with the demand from day to day. Hence, deliveries can be made quickly at the most opportune time to take advantage of market activity, and transportation costs are low. Freshness and attractiveness, when vegetables are handled properly, increase the possibility of obtaining best prices and the expense for packaging may be relatively low. Local growers enjoy numerous advantages including, in many places, decided preference for homegrown produce.

At a distance from populous areas the requirements for a favorable outlet may be met by proximity to (1) established community packing and shipping stations, (2) important regional markets where buyers gather, (3) an auction market in the country, or, (4) a cannery or other processing plant.

Transportation facilities.—A hard-surfaced road from farm to market, shipping point, or cannery is practically essential. An unimproved road, however, may be adequate when the principal crops are marketed during the summer and early fall. Bad roads limit the size of loads; increase wear, tear, and time of hauling; cause bruising of tender vegetables, and reduce or eliminate possibilities of attracting buyers to the farm. Locating on some important highway may provide substantial possibilities for wholesale selling at the packing house and there are widespread opportunities for retail roadside marketing.

Shipping facilities should be studied carefully before engaging in trucking at remote places. Railway shipping by freight and express should be investigated with respect to schedules, refrigerator service, car supply, terminal facilities, and rates for transportation and for special services. The possibilities and costs of highway transportation also should be determined. Increasing tonnage of vegetables is moved to market by motor truck operators who specialize in hauling for growers. In some localities transportation by water is most advantageous for certain crops.

Climate.—Immense areas in various parts of the South and Southwest are planted in truck crops because climatic conditions make it possible to place the vegetables on northern markets before local supplies mature. Yields southward are not usually larger. It may be possible, however, to remove more crops from the same area in a season. The long and warm seasons are favorable also for the use of soil improvement crops.

The cooler sections of the North also have advantages. Insect and fungous pests are less troublesome than in the South. There is not so much leaching of nutrients from the soil during the winter and the cooler weather is favorable to the summer culture of certain crops as potato, cabbage, cauliflower, celery, lettuce, pea, and onion. Considerable quantities of these are shipped South during the warmer parts of the year.

Large bodies of water may produce favorable climatic conditions for certain crops. The success of cauliflower on Long Island is largely attributable to influences from the sea. The winter season at Norfolk is shortened and made milder by the Gulf Stream. In lake districts there is much less damage from frosts in late spring and early fall than in similar latitudes where water influence is lacking. Within a few miles, differences in altitude may provide great variations in climate. In fact, material differences may exist within a county in respect to temperature, amount and seasonal distribution of rainfall, humidity, wind, and hours of sunlight. There is often opportunity to capitalize these differences by producing crops

that will mature before or after the peak period of local marketing or that are not commonly grown to advantage in the community.

Topography.—It should be noted that gentle slopes usually provide good air drainage, which may be an important consideration in reducing risk from frost. Steep hills should be avoided. Perhaps gullying may be prevented, but sheet erosion is nearly certain to carry away progressively the best topsoil more rapidly than the land can be improved. Machinery can not be used to good advantage on hillsides, and the effects of drought are likely to be most severe. Gardeners who follow intensive methods generally use gentle slopes or level lands. It is difficult if not impossibe for the truck farmer to reduce costs to a competitive basis with the handicap of very hilly land.

Southern or southeastern exposures are desirable for certain enterprises. A sunny slope dries off and warms up earlier in the spring, makes earlier planting possible, and matures the crop more rapidly than ground sloping to the north. The fuel bill is lower in greenhouse operation and plant growing is easier. Crops will not be whipped and injured so much by the wind. However, level land characterized by good air and water drainage is more generally desirable. Crops are nearly as early as on southern slopes.

Windbreaks, natural or artificial, in the forms of hedges, trees, walls, or buildings, may be an asset, and in some locations are a necessity.

Water supply.—A dependable, abundant, and inexpensive supply of pure water should be certain before a location for most lines of vegetable growing is decided upon. An immense quantity of water is required to meet the needs of plant growing and of greenhouse crops, to wash or pre-cool vegetables for market, to spray, and to supply the livestock that may be kept. If irrigation is planned, very large quantities of water will be required, as it takes approximately 27,000 gallons to apply an inch of water to one acre. Accurate determination of flow should be made, unless probable sources are obviously ample.

Labor supply.—If many laborers will be needed because of the extent or intensity of operations, the availability of sufficient help must be determined as well as the experience or adaptability of the people. In some cases this problem may be solved by close proximity to a city or a town; otherwise, it may be necessary to provide transportation for the workers. Perhaps cottages can be erected on the farm.

The number of men that might be required ranges from one to the acre in the most intensive market gardening to one for three to

15 acres in truck farming. Several hands to the acre will be required when picking peas or beans for market. For light work of a seasonal nature, such as setting onions or plants and gathering certain crops, many gardeners depend on young people who work after school hours or during vacation.

Costs of supplies.—Differences in cost of important supplies may have considerable bearing in choosing a location. For example, the prospect of an ample and reasonably priced tonnage of manure would be favorable for the choice of a relatively high-priced, perhaps small, acreage close to market. It is more likely that costly, limited

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FIG. 2.—The labor supply and level land are important considerations in locating a vegetable farm.

supplies of manure would make preferable the choice of more and cheaper land where overhead costs would be lower and liberal use could be made of soil improving crops. Costs of fertilizer, lime, fuel, and packages may vary considerably within the local marketing or shipping radius of a given market.

The community.—In addition to selecting, if possible, a community where social, school, and church relationships will be pleasant, there may be important business reasons for locating where many growers are interested in the same crops. Group or community cooperation in buying supplies, in packing, and in selling produce may be of great advantage.

SOILS

Practically all good agricultural soils will, with proper treatment, produce fair or good crops of most vegetables. Favorable soil conditions, though, are exceedingly important, and should be considered carefully in selecting a location. Good drainage is essential.

Sandy soils.—Adaptations of soils to particular crops or types of gardening are determined largely by their texture. The advantages of sandy soils for vegetables may be enumerated as follows: (1) The land dries off quickly and warms up earlier in the spring, and maintains a higher temperature than fine-textured or heavy soils; (2) operations may begin earlier in the spring and continue later in the fall; (3) tillage is less expensive; (4) cultivation may begin sooner after rains; (5) transplanting is facilitated; (6) the harvesting of many crops is easier; (7) sandy soils do not become so hard and compact; (8) rainfall or irrigation water is quickly absorbed; (9) the root vegetables are better formed and have fewer fibrous roots; (10) many crops require less work in cleaning and preparing for market. The soils of many of the important trucking regions contain considerable sand.

Coarse sand is a "quick" soil because it is well drained and dries out and, consequently, warms up very early in the spring and makes early planting possible. Again, the coarse sands are warmer during the entire period of growth, thus hastening early maturity. Such soils require frequent additions of organic matter and liberal, wisely regulated fertilization. Irrigation is usually a great advantage and may be a necessity. Expenditures for manures, fertilizers, and perhaps for irrigation, are relatively high. The medium sands are not quite so early, but they are more productive and somewhat more retentive of moisture and nutrients.

The fine sands and sandy loams are often our best trucking soils; although not quite so early as the more porous soils, they are usually more productive. They are most suitable for a general line of crops.

Silt and clay loams of the more fertile series are very valuable for certain late market and cannery crops. The maintenance of fertility is less expensive on heavier types of soil and yields usually average higher. Late cabbage and late tomatoes, for example, succeed on some very heavy soils when organic matter is adequate. The lighter phases of heavy soils produce good early crops. Lima beans do best on sandy soils, while field beans prefer the heavier types.

Muck soils and well decomposed peats are of great commercial importance in the production of celery, lettuce, and onions, although the root crops and all leafy vegetables may be grown to advantage.

Yields are high on the average. These soils are formed by the accumulation of decayed plant material and are characterized by great water-holding capacity. In the North they are especially adapted to summer production of the more succulent crops. Mucks are slow to warm in the spring, are subject to frosts, and generally require liberal proportions of potash in the fertilizer mixture. Newly cleared and drained muck rarely produces satisfactory crops of vegetables. The customary preparation is to grow general farm crops for one to three years. Applications of manure and lime aid conditioning, although some mucks do not need lime (p. 249). The quality of mucks and peats is extremely variable. An inexperienced grower should secure expert counsel in selecting a location.

Appraising the soil.—In selecting a soil for vegetable growing, good texture and structure are paramount considerations. Deficiency of organic matter or nutrients usually can be remedied by liberal use of manure, or by growing soil improving crops with appropriate applications of lime and fertilizers. It is impracticable, however, to expect revolutionary changes in the physical characteristics of very fine and compact clay. Such soils are extremely resistant to modification, although a small garden may be improved by large applications of manure, lime, and gravel, coarse sand, ashes or cinders. Moderately heavy soils in the field can be improved materially by systematic employment of the various practices of good farming.

Other very important considerations are the nature and condition of the subsoil, depth of the furrow-slice, and drainage. Particular attention should be given to the suitability of the soil for intended crops and seasons of production.

III

SEEDS

The planting of good seed is essential to success and warrants as thoroughgoing consideration as any other factor in the vegetable growing business. Nearly a hundred years ago Peter Henderson stated: "If there is one thing of paramount importance in vegetable gardening it is purity of seed." He spoke from the experience of a long and active life as a practical commercial grower. More recently J. B. S. Norton, well known plant breeder, observed: "At no point in the production of crops can greater results be obtained with less effort than with the seed."

CHARACTERISTICS OF GOOD SEED

Good seed is characterized by high vitality, good breeding, freedom from disease, suitability for the conditions, and freedom from foreign matter, such as weed seeds, stems, or dirt.

Importance of high vitality.—For commercial purposes it is not enough that seeds should be merely viable. They must have the vitality to germinate with vigor, to assure good stands of thrifty, quickly-starting plants under the varying conditions that are encountered. Thin stands of plants plainly reduce yields, but it also is true that weakly germinating seeds are most unlikely to grow into strong, heavily-yielding plants. Germination tests should be conducted and interpreted, therefore, to indicate as reliably as possible the performance to be expected in the field.

Germination testing on the farm is necessary, particularly with seed carried over from year to year, both to avoid the possibility of planting dead seed and to provide a basis for regulating the rate of sowing. Samples of 25, 50, or 100 seeds may be put between folds of moist blotting paper or cloth and placed between two dinner plates turned together. Or, to simulate field conditions to a better degree, the samples may be sown in rows in shallow boxes of soil. A warm room will be suitable in temperature, and water must be added from time to time to keep the seeds moist but not wet. The percentage of seeds of high vitality and vigor will be indicated as a rule by the number which sprout promptly and more or less at one time. The slow and weak sprouting seeds may be counted for total percentage of germination, but many of these will fail to produce worthwhile plants outdoors.

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FIG. 3—Germination testing, rag-doll method.

The practical longevity of seeds, when properly cured and stored, is approximately as follows, stated in terms of years:

Cole crops; broccoli, Brussels sprouts, cabbage, cauliflower, and Chinese cabbage 3-5.
Solanaceous crops; pepper 3-4, tomato 4-5, and eggplant 5-6.
Leguminous crops; peas and beans 2-3.
Cucurbitous crops; cucumber, pumpkin, squash, and watermelon 4-5.
Root crops; parsnip and salsify 1-2, carrot 2, beet and radish 3-4, rutabaga and turnip 4-5.
Others; asparagus 2-3, onion 1-2, sweet corn 1-2, lettuce and spinach 4-5.

Older seeds should not be discarded without testing, however, because satisfactory viability may be retained much longer, sometimes 10 years or more, in tomato and cucumber seeds and 8 years in celery. On the contrary, longevity may be only a year or less where humidity is very high. Ordinary extremes of temperature, however, are unlikely to harm well-cured seeds. A germination test is the only safe guide. Different lots of the same kind of seeds may be unlike in inherent keeping quality, storage conditions may vary, and there may be uncertainty concerning the age of seeds when received.

In planting outdoors it is nearly always an advantage to use reasonably fresh seeds, as they usually germinate more quickly and uniformly. In starting plants under glass poor germination is not particularly disadvantageous, if this fact is known in advance so that sowing may be at a compensating rate. The weak seedlings may be eliminated when transplanting. Thus, extremely old seeds, of proved worth but very low germination, may be preferable under some circumstances to new unproved seeds of high vitality. In certain cases old seeds may outlive seed-borne diseases.

Size and weight of seeds in relation to yield.—The larger and better filled seeds from a given lot excel in vitality and can be depended upon, in the experience of both growers and investigators, to give earlier, more uniform, and heavier yields. Stronger plants probably spring from the large plump seeds on account of the greater amounts of stored food available for the support of the seedling until the roots and leaves begin to function. The better commercial seeds are graded quite closely by machines which employ screens, windmills, and centrifugal forces. Some exacting growers go even further and subject certain seeds, radish for example, to additional very severe sifting.

Good breeding in seeds implies excellence of inherited characteristics, the ability to produce as expected. The potentialities of well-bred seeds include much more than mere trueness to type as indicated by appearance. Notable improvements are continually being made in productivity, resistance to disease or insects, attractiveness of form and color, time and uniformity of maturity, types of growth to suit specific climatic conditions, and special qualities for the table, shipping, canning, or freezing. Pure-line stocks and first filial generation, F_1, hybrids exemplify the advanced breeding that enables the seedsman to sell and the gardener to buy a specific thing that will perform in a consistent and predetermined manner under given conditions.

Freedom from disease is a characteristic of great importance in seeds, not only in respect to the possible effects of seed-borne diseases on the one crop, but also to avoid contaminating the premises. Clean seeds of a number of crops are available to the discriminating buyer and may be produced under relatively disease-free conditions, such as at high altitudes, or by rigid control. Heat or chemical treatment (p. 22) of other seeds may be necessary and can be applied by the grower if it has been neglected by the seedsman.

Suitability of seeds for the conditions.—Seeds of some kinds and varieties do well at appropriate seasons in practically all parts of the country. Others are limited in usefulness to certain regions, seasons, or market requirements. For example, Golden Early Market is one of the best extra early varieties of sweet corn but it is so

susceptible to bacterial wilt that it is valueless where the disease is prevalent. As an example of seasonal suitability, Long Standing Bloomsdale is a valuable variety of spinach for spring planting because it goes to seed slowly, Virginia Blight Resistant Savoy is resistant to "yellows" in the fall, and Old Dominion withstands overwintering relatively well and is slow to go to seed. For the main crop in hot climates, a tomato variety should produce dense foliage to protect the fruits from sun-scald, but lighter foliage is preferable for the very early crop and for cool regions.

BUYING SEEDS

Varieties.—The first problem is to decide exactly what you want. It is helpful to refer to a list of standard varieties. Many of the agricultural colleges prepare lists of varieties that are adapted to their conditions, and a list of the more important varieties is included in the Appendix of this volume. In time, the experienced grower develops a private list of varieties or strains and sources proved in his own plantings. In ordering seeds he usually specifies stock numbers to insure identity of parentage lines.

It is of great help to maintain personal or correspondence contacts with some of the trained vegetable specialists in the seed trade. They, and the reputable houses which they represent, are anxious

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FIG. 4—Maintenance of trial grounds is an important activity with seedsmen and many experiment stations.

to serve the grower in his choice of seeds, and, from their wide experience, they are especially well qualified to do this. The best catalogues carry trustworthy descriptions and are worthy of serious study.

Most seedsmen have specialties in which they take great pride, and it often pays to patronize them when their varieties are wanted. Good seeds usually cost more than poor ones, but it pays to buy the best. Ordinary differences in price are of secondary importance.

A few growers buy seeds of certain crops a year in advance, plant trial rows, and always have seeds of proved productive ability for their principal plantings.

Novelties.—A widely heralded novelty or apparent improvement may have been developed for special conditions or its promise of superiority may not be fulfilled. All standard varieties, however, were once novelties, although comparatively few of the new offerings become of general value. The trial grounds of seedsmen and experiment stations will eliminate most of them. But the grower, to be sure he always is planting the best, must test the few most promising introductions. A sample packet is sufficient, at first, with limited commercial areas of the best ones to be planted later.

Quantities of seeds required.—The seed requirement varies greatly with soil types, temperature, moisture supply, planting distances, vitality of seed, varietal differences, and skill of the planter. The most satisfactory rate of sowing often may be one-half more or less than the customary quantities indicated in the table found in the Appendix (p. 506).

SEED GROWING

Home production of seeds.—As a rule the well informed and discriminating grower can buy fine, dependable seeds more cheaply than he can grow them. Many growers and organizations, however, have developed seed stocks of outstanding performance, of which the plant and crop characteristics have been bred to fulfill particular requirements of soil, climate, culture, and market. Improvement is dependent upon application of scientific methods and it may be difficult to attain much improvement with certain of the well bred stocks commonly available today.

What seeds to produce at home.—Seeds of tomato, pepper, eggplant, sweet corn, cucurbits, lettuce, and parsnips may be produced most conveniently and simply, sometimes with improvement and economy. Radish and spinach seed also can be saved without difficulty. Seed peas and beans, unless carefully controlled, may carry excessive percentages of disease when produced in humid regions. The biennial plants, beets, carrots, celery, onions, and most members of the cabbage family, must be stored over winter in cold

climates and replanted in the spring to produce seed, or the natural rest period may be simulated by artificial conditions. It is impossible to include details for each kind. A brief discussion of seed growing, however, is included in several of the chapters devoted to the different crops.

Procedure in home production of seeds.—The first step is to begin with the best stock that is available of the variety to be grown. The next step is selection, which must be on the basis of the plant as a unit. Little or nothing will be gained by selecting fine tomatoes from the pickers' baskets. Generally a shapely tomato from a plant bearing many ill-formed specimens is worthless but all the fruits on a desirable plant are equally valuable for seed purposes. Better results will be secured if a number of promising plants are marked as maturity approaches, and then kept under observation until the final selections are made. Earliness, yield, type, vigor, quality, resistance to disease, and other pertinent characteristics must be appraised. When the seeds from all the selected plants are put together the method is known as mass selection and often is decidedly worth the effort. A simple variation is to save the seeds of individual plants separately, make test plantings of the progenies and continue to work with the most promising.

Pure lines.—A more ambitious procedure is to develop pure lines, that is, stocks which are bred to a state of great purity. Briefly, pure lines are created by selecting promising plants, preventing cross-pollination, testing the progenies of each "selfed" plant, discarding the undesirables, and repeating the processes of selfing, testing, and selecting until the type is fixed. Valuable results often may be secured, especially with stocks that are mixed and the procedure may not be too technical for the grower who becomes a student of the subject. Recombination by controlled crossing of promising lines sometimes produces outstanding results.

Cross-pollination in vegetable plants.—Tomatoes, peppers, eggplants, peas, beans, and lettuce are naturally self-pollinated, and cross-pollinate or "mix" to only a small extent, usually not to exceed five per cent. The cucurbits, carrot, celery, and parsnip are self-fertile but are often cross-pollinated. The naturally cross-pollinated vegetable plants are asparagus, sweet corn, beets, onions, spinach, and the cole crops. Widely separated plantings of different varieties of any often cross-pollinated or naturally cross-pollinated plant are required to prevent serious mixing.

Harvesting, cleaning, and curing.—Most seeds should not be harvested until they are fully ripe or mature. Some seeds must be gathered when slightly immature, however, in order to avoid excessive losses from shattering. It is important to be prompt in gathering the crop when the proper time has arrived. If sprouting

molding does not occur, the seeds will discolor if left too long on the stalk. Seeds are generally ripe when the pods or seed capsules turn yellow, or the fruits, as tomatoes and melons, lose their firmness.

Bright, sunny weather should be selected, if possible, for the harvesting of crops which require threshing. The plants should be thoroughly dried before separating the seeds. Whatever the method, whether by flailing or by machines, the greatest care should be exercised to prevent breaking the seeds or injuring the seed coats. Windmilling is necessary for further cleaning of the seed.

A common method with tomatoes, melons, and cucumbers is to place the cut or crushed fruits, or sometimes the pulp, in any convenient vessel, as a crock, tub or barrel, and stir daily until fermentation in the vegetable's own juices has loosened the covering about each seed. To prevent the discoloring or sprouting of seeds, the fermentative process should not be continued longer than necessary.

The seeds are separated from the pulp and the skin by washing and decanting as often as may be required. The good seeds settle to the bottom of the vessel, while pulp, skin and light seeds rise to the top, and may be poured off. Three or four washings are usually sufficient. Sieves are often used in the process of separation by washing.

After windmilling or washing the seeds must be dried before storing. They should be spread in thin layers in lofts, or in dry, well-ventilated places until thoroughly dry. It is an advantage to

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FIG. 5.—Typical seed-growing area in Rocky Mountains. High altitude, low humidity, warm sunny days and cool nights aid in the production of relatively disease-free seed, especially of peas and beans.

wash seeds early in the morning of bright days to facilitate drying. Seeds must not be subjected to freezing temperatures before being cured, for this invariably impairs their germinating power.

Commercial production of vegetable seeds has become a vast and highly specialized industry. Trained plant breeders and expert seed growers combine their efforts to produce a large tonnage of well bred seeds. The farflung industry avails itself of widely separated favorable conditions for the production of various kinds of seeds; lettuce, carrot, celery, and many others in California; peas and beans at high altitudes in the Rocky Mountains; muskmelons in Colorado; and cabbage and cauliflower in the Puget Sound district.

The usual commercial procedure is in two stages; first, the production of fine stock seed under the direct supervision of specialists, and, second, the production of commercial quantities by contract growers who are furnished the stock seed.

Storage of seeds.—The most important factor in preserving seeds is to cure them thoroughly. When the excess moisture has been eliminated from seeds and the humidity is low they keep well under ordinary extremes of temperature. Doubtless more seeds are destroyed by vermin than by unfavorable conditions on the farm during storage. Tight cupboards, cans, or a vermin-proof seed room are necessary. Moth balls are useful in repelling insects. Carbon disulphide may be used as a fumigant to kill seed-destroying insects (p. 181). Correct storage includes labeling of seed packages both inside and outside with variety name, strain or breeding data, source, and the year it was grown or received. In warm humid climates cool dry storage is desirable and it may be necessary to store the thoroughly dried seeds in tightly sealed, air-tight containers.

SEED TREATMENTS

Most vegetable seeds should be treated with a disinfectant befor planting. The purpose may be to destroy seed-borne diseases o to afford the germinating seed some protection from damping-o organisms usually present in the soil, or it may be that both objec tives are sought. Many seedsmen will supply treated seeds; othe wise, the planter should apply appropriate treatments.

What treatments to apply.—The following schedule of veg table seed treatments has been compiled from the recommendatio of several experiment stations and commercial organizations. Min variations exist in the recommendations of authorities. Insof as possible the preferred treatments have been indicated; howeve the difference in efficiency of control or in safety to the seed may slight in many cases, and some of the materials, with research a

experience, may prove useful for purposes which are not shown in the table.

VEGETABLE SEED TREATMENTS

Seed	*Wet Treatment* [x] *(Apply first)*	*Dry Treatment* [x] *Apply only one. Seed must be dry.*		
		Red Copper Oxide (Cuprous oxide)	*Zinc Oxide*	*Semesan, Semesan Jr., Semesan Bel, Ceresan* ‡
Asparagus *				
Bean, common *			2	1
Bean, Lima *		2	1	
Beet		1		2
Cole Crops— Cabbage	Hot water 122°F. 25 minutes			
Broccoli Brussels Sprouts Cauliflower	Hot water 122°F. 18 minutes. Cool and dry.		2	1
Carrot		1	2	
Celery	Bichloride of Mer.†		1	1
Corn, sweet				1
Cucurbits Cucumber Melons Pumpkins Squashes	Bichloride of mercury 1-3000 10 minutes or 1-1000 5 minutes. Wash and dry.	2	1	
Lettuce		1	2	
Onion		2	2	1
Parsnip		2	1	
Pea		1	2	1
Potato	See page 416			Use as a Dip ‡
Radish Rutabaga Turnip	Bichloride of mercury treat. often advisable	2	1	
Tomato ** Eggplant Pepper	Bichloride of mercury as for Cucurbits	1	2	2
Spinach		2	1	
Sweet Potato	See page 419			Use as a Dip ‡

* Usually not treated. † See also Calomel treatment.[x]

[x] Details are found in the pages that follow. Numerals indicate order of general preference of treatments.

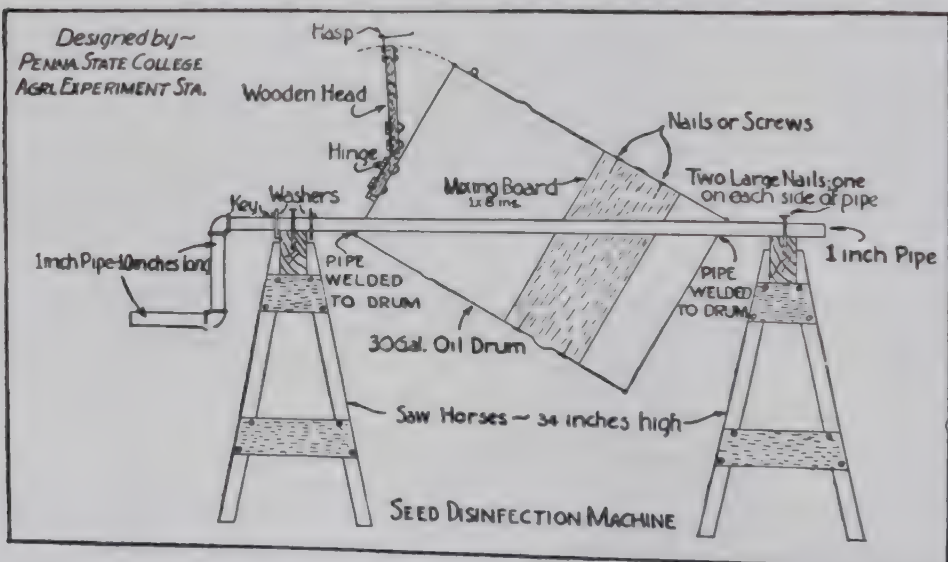
‡ Follow manufacturer's directions.

** Hot water treatment, as for cole crops, is especially effective.

Hot water treatment is necessary to kill organisms commonly found inside the seed coat of cabbage and related crops. Secure fresh seed if possible as the treatment may seriously reduce germination of old seed. Place the seed in bags of cheesecloth or other thinly woven material but have the bags only half full to permit the manipulation necessary to assure prompt soaking of every seed.

Use an accurate thermometer. Temperatures one or two degree too high may injure the seed; temperatures slightly below the recom mendation may permit the fungi to escape. The correct temperatur is 122° F. Uniform temperatures are maintained most readily b using large vessels and by adding hotter water slowly as requirec stirring continuously. The period of treatment is 25 minutes fo cabbage and 15 to 18 minutes for cauliflower, broccoli, Brussel sprouts, and the other cole crops. At the end of that time the see should be dipped immediately in cool water. It must be drie thoroughly for storing. After drying it may be treated with zin oxide or semesan.

Corrosive sublimate or bichloride of mercury treatment i standard for seeds of the cucurbits and tomato and in some instance is recommended for eggplant and pepper. Its use for the potato an sweet potato is described later (pp. 416, 419). For most seeds a solu tion of one part of bichloride of mercury in 3000 parts of water i recommended. Small quantities may be prepared conveniently wit



The Pennsylvania State College

FIG. 6.—Home-made seed disinfection machine. It is suitable also for mixing dusts.

the tablets sold at drug stores. Follow the druggist's directions fc a 1-3000 solution. For larger quantities use one gram to thre quarts or one ounce to 23 gallons of water. Corrosive sublimat will dissolve quickly in a little hot water but the solution must b cool when used. Glass, earthen, or wooden containers are necessar because mercury solutions corrode metal. For best results use th solution only once and at the rate of one gallon or more for eac pound of seed. The seed is immersed for ten minutes and must b

worked about to assure thorough wetting. Finally it is rinsed very thoroughly in several changes of fresh water and spread in a warm, airy place. Treated seeds may be sown as soon as they are dry enough to handle or they may be dried thoroughly and stored. Additional treatment with red copper oxide, organic mercury, or zinc oxide dust often is advantageous as protection against pre-emergence damping-off.

Celery seed may be soaked a half hour in lukewarm water, drained, soaked 30 minutes in a one to 1000 solution (1/8 ounce to one gallon) of corrosive sublimate, and washed. A gallon of solution will treat a pound of seed and should be used only once.

Calomel treatment.—Another method with celery seed is to soak the seed in a suspension of one ounce of calomel in one gallon of water until it is thoroughly wet, about two or three minutes, during which time the bag is manipulated. Plant as soon as possible or dry and plant within a few weeks. Do not rinse or apply any additional treatment after using calomel.

Calomel may be applied to cabbage seed to combat maggots in the outdoor plant bed as described later (p. 234).

Dry or dust treatments with red copper oxide, zinc oxide or organic mercury are particularly valuable for their protective effect in combating "seed rots" and "damping off" and they also may destroy certain organisms borne on the seed coat. Suitable materials for the different seeds already have been suggested. In general the recommendations of the manufacturers should be followed. Red copper oxide (cuprous oxide) should be bright red in color and very fine. Organic mercury disinfectants are of several types and must be purchased in the form suitable for the particular purpose.

The procedure is so simple and inexpensive that it should not be neglected by any grower. The seed and required amount of the dust are placed in a convenient container of ample size which is closed tightly and shaken vigorously or rotated for several minutes to assure even coating of every seed. Screen out any excess material and store the seed in a dry place until planted.

Dosages vary with size of seed and nature of seed coat. With red copper oxide and zinc oxide the approximate amounts are one-half teaspoonful to the pound of small, smooth-coated seeds and a level teaspoonful to the pound of small rough-coated seeds, that is, about one-third to one ounce of disinfectant to the pound of seed. About two and one-half ounces of material will treat 100 pounds of peas or seeds of the cucurbits, and two to two and one-half pounds may be applied to 100 pounds of spinach seed. Rates with organic mercury dusts are indicated by the manufacturers.

Unusual friction in drilling may follow certain dust treatments particularly red copper oxide. In extreme cases many of the seed

coats may be cracked or the drill may be broken. Smooth drilling may be attained at insignificant expense by including powdered amorphous graphite of the finest grade in the treatment. The quantity required may be half or as much as the amount of the disinfectant.

Precautions.—The margin of safety between killing the fungi and injuring the seed may be narrow, especially with heat or liquid applications. Exact temperatures or dilutions and length of treatment are essential.

Safety of persons and animals requires immediate disposal of solutions and rinse water. All seed disinfectants are poisonous if taken internally. Corrosive sublimate is deadly. Avoid inhaling the dusts.

After liquid treatments it may be convenient to plant the seeds while still moist, but do not soak treated seed before planting or dust moist seed heavily. Injury may follow if dust-treated seed is planted in pure sand, or in dry soils that are low in organic matter. Do not treat seeds previously treated by the seedsman. Water promptly after sowing and do not allow the soil to become very dry.

It is futile to disinfect seed and plant it in disease-infected soil. Sterilize the plant-bed (p. 44) or secure new soil. The practices of rotation and sanitation assure relatively disease-free soils in the field.

IV

PLANT GROWING

THE cole crops, solanaceous fruits, and celery almost invariab are grown by transplanting young plants which have been started plant beds. This is true with the crops named, even when clima or desired season of maturity permit sowing in the field.

Satisfactory yields of tomatoes, peppers, eggplants, and sw potatoes cannot be secured without the use of glass or other prot tion in the North and it is necessary for their early production many parts of the South. Early yields of cabbage, cauliflow celery, and lettuce require the use of glass wherever these crops ca not be grown outdoors over winter. Glass is often used to advan the season of beets, muskmelons, cucumbers, and Spanish ty onions. It is evident that most vegetable growers, particularly tho with a diversity of crops, must either grow or buy plants.

Uses of glass.—The term glass, as used here, includes the ma types of hotbeds, planthouses, and coldframes. The most comm use of glass is in plant growing, that is, in producing plants ready be transplanted to the open ground as soon as conditions perm Glass also is used extensively in vegetable forcing, both in growi

FIG. 8.—Convenient plant growing lay-out with sash houses, coldframes, boiler an work room, and adjoining shed for storing and steaming soil.

vegetables partly or entirely to maturity in hotbeds or coldframes, in very early spring or late fall, and in growing crops to maturity in greenhouses at times when it is impossible to produce them in the open in the locality. Details of plant growing are discussed in this chapter and of vegetable forcing in Chapter XXV.

Advantages of starting plants under glass.—Most of the advantages of growing plants for early transplanting into the open ground are secured as a result of earlier maturity. They include: higher prices, as a rule, for the first crops placed on the markets; larger yields, which may be due to a stronger start, earlier and longer fruitful period with fuller maturity before fall frosts destroy the plants; ability to grow long-season crops that can not be produced otherwise; and earlier release of the land for use of succeeding cash crops or soil improving crops. An important additional advantage under many conditions is that weeds are less difficult to overcome when plants of good size are set in the garden or field. The ravages of insects and diseases may be less destructive and more easily controlled when strong, clean plants are used.

HOTBEDS

Uses of hotbeds.—Before greenhouses became so popular as they are today, hotbeds were universally employed whenever glass was required to start early plants. Although hotbeds, in many cases, have been replaced by greenhouses, they are still used extensively. Many renters depend upon hotbeds, because they may be forced to vacate the property upon short notice and are naturally unwilling to spend much money in constructing permanent greenhouses. Hotbeds are inexpensive, and the amount of space devoted to them may be increased from year to year without much outlay. In addition, they do not require attention at night, as do the furnaces of greenhouses. On the other hand, hotbeds are inferior to greenhouses in many particulars, although with skilful management they produce excellent results.

Early hotbeds and planthouses are used mainly to produce seedlings, which, when transplanted two to four weeks after sowing, will fill 5 to 10 times as great an area of coldframes or mild hotbeds.

Location and arrangement.—Hotbeds should be located so that a liberal supply of water is accessible. Hose connections should be placed between the frames, at intervals not exceeding 100 feet.

The hotbeds should be convenient also to the farm buildings, and to a room which can be made warm and comfortable for the work of sowing and transplanting. They require frequent attention some days, and a convenient location is important.

Protection from severe north and west winds is a great advan-

tage. This may be secured by natural windbreaks, such as hills and trees. Buildings also may serve the purpose. A common practice is to plant hedges or to construct board walls 5 or 6 feet high for this purpose. The walls may be used also to support the mats while drying.

South or southeastern exposures are preferable to others. The frames should run parallel with each other, with ample space between them for alleys or roadways, for the handling of mats and sash, and for snow shoveled from the glass. To serve these purposes best there should be at least 10 feet between the frames, but when the land is high priced and limited in area it is economical to make the alleys about 2 feet wide. These alleys are often filled with manure to help retain the heat of the hotbeds.

The pit.—Most hotbeds are heated by the fermentation of manures in pits excavated for this purpose. The first essential of the pit is good drainage, natural or artificial. Artificial drainage may be provided by running tile from the bottom of the pit. In most soils, however, this precaution is unnecessary. The pit should be dug in the fall before the ground is frozen, and a few inches of leaves or coarse manure placed in the bottom during the winter. It should be of the same width as the frame and of any desired length.

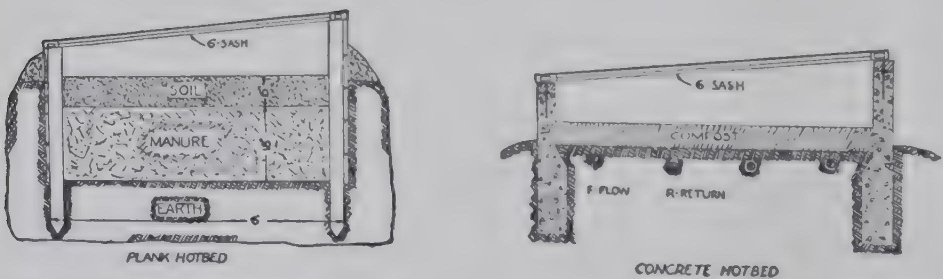


FIG. 9.—Typical plank and concrete hotbed construction. Manure or artificial heat may be used in either type.

The proper depth of the pit depends upon several factors. In the North it is customary to use 15 to 30 inches of manure. The pit should, therefore, be a few inches deeper than the depth of the manure. For starting early cabbage and lettuce plants in the North, 18 inches of good manure are ample, while 24 to 30 would not be too much in forwarding the eggplant, which requires a high temperature for seven or eight weeks. Tender plants, like tomato and pepper, also require more manure. Southward, the depths of manure vary from 6 to 12 inches. The kind of manure used and the length of time the hotbed will be needed also determine the proper depth of the pit.

The frame.—The frame may be of wood, concrete, brick, or stone. The most common material is a durable wood. The usual plan is to use either locust or cedar for the posts, and other lumber for the sides and crossbars. The frame may be of any desired length, and wide enough to accommodate the sash. That is, the width of the frame at the top should be about one inch less than the length of the sash.

The upper or north side of the frame should be 6 inches higher than the lower or south side, in order to give the proper slope. This can be accomplished easily by using 6 and 12-inch widths. Usually one 6-inch and two 12-inch boards or planks are sufficient for the upper side of the pit, and two 12-inch pieces for the lower side; the boards should always extend to the bottom of the pit. The posts should be made of strong round stakes or of 2x4-inch or heavier lumber. It is generally necessary to remove some soil at the sides of the pit where the posts are to be placed. The best frame will be made if the boards are not more than 12 feet long, and posts are driven at the ends and midway between.

Crossbars or slides are not always provided, but they possess so many advantages that hotbeds should seldom be made without them. A 2x4-inch piece is about the right size, and should be sound and surfaced on the upper side. Some gardeners prefer a ½-inch strip in the middle of each crosspiece to guide the sash—a provision that is well worth while making. The sash can then be handled with much less annoyance.

When placing the crossbars, great care should be exercised, for if they are too close together the sash will bind and greatly annoy the attendant. If the sash are 3 feet wide, the distance from center to center of the crossbars should be at least ½ inch more than 3 feet.

Sash.—The most durable wood should be used in making hotbed and cold frame sash. Cypress or redwood is usually employed. The standard and most popular size is 3x6 feet. Sash vary also in thickness; the lighter 1⅜-inch sash are easier to handle and most popular, while the heavier 1¾-inch ones are stronger and sustain less breakage from hard winds and handling.

Before purchasing sash, inquiry should be made regarding the type of construction. The joints should always be leaded before the parts are put together, and less moisture will be absorbed in the corners if the tenons do not extend through the side-bars, a method of construction known as blind mortising. A light iron or wood rod across the middle of the bars strengthens the sash and prevents spreading.

A priming coat of paint should be applied before glazing. It is always desirable to buy glass of good quality, although cheaper grades are often used for this purpose. Double strength B is satis-

factory. Some gardeners prefer to butt the glass. When this is to be done, the sash should be ordered with grooves cut in the sash bars in which the glass slides; but unless the ends of the panes fit very closely there will be considerable leakage, for which reason lapping is more popular. The glass need not lap more than ¼ inch. A 3x6-foot sash is usually made for three runs of 10x12-inch glass, requiring 18 panes for each sash. The glass is fastened by glazing points, and the putty or glazing material is applied in the angles formed by the glass and the sash-bars. A better plan is to lay the glass in putty. After glazing, the sash should again be painted, and the painting repeated every year or two thereafter. When not in use they should be stored in a dry place, or stacked. In the latter case several of the upper sash should be nailed together with vertical strips to prevent the wind from lifting and breaking them. If the glazing is done at home and glass is bought in wholesale lots, the sash can be made in lots of 50 or more at a cost not exceeding $2.50 to $3 each.

Glass substitutes.—Various glass substitutes sometimes are used to cover hotbeds or other plant-growing structures. Probably the most economical and generally useful glass substitute is closely woven unbleached muslin, preferably waterproofed (p. 41). Oiled paper, special waterproofed cloth, and glass substitutes of cellulose built on wire screen bases also are used. Light transmission is poor, as a rule, and lack of durability may make them as expensive as glass. Growers who are not engaged in growing very early plants, and therefore can remove the covering more frequently to admit sunlight, often secure excellent results with glass substitutes.

Manure and its preparation.—Fresh or fairly fresh horse manure, from animals receiving grain in the ration and containing about half as much litter as excrement, is most generally suitable for making hotbeds. Manure with shavings as litter is not satisfactory. Synthetic manure (p. 91) may be used if necessary. Fermentation of very strawy manure can be promoted by adding nitrogen in the form of fertilizer.

Sometimes manure, as piled at the stable or as received in shipment, may be evenly heated and of the correct degree of moisture for the pit. Preparation of the manure, however, usually is required and should begin about 10 days before the date for sowing or planting. Correct preparation of suitable manure assures proper heating in the hotbed.

It is the common practice to pile the manure 3 or 4 feet high, about 5 feet wide, and to the length required to supply the quantity needed. If the manure is comparatively dry, hot water—although cold water will do—should be sprinkled on it as the piling progresses. A certain amount of compacting by tramping also encourages fe

mentation and reduces fire fanging. Ordinarily the pile will begin to steam in a day or two. When fermentation is well under way the manure may be suitable for placing in the pit. On the other hand, it is likely to be advisable to turn the pile, break all lumps, and place the exterior of the old pile on the interior of the new pile. When the entire mass is heating, usually in two or three days, the pit should be filled.

The manure should be placed in the pit in successive layers of about 6 inches and tramped firmly, especially along the sides and in the corners. If the manure is too dry to pack, it should be sprinkled with sufficient water to make it firm and resilient under foot but not wet and soggy. Allowance should be made for several inches of settling and for 4 to 6 inches of soil to receive the seeds or plants. If plant boxes, or flats as they are called, are to be used, 2 inches of soil over the manure will be sufficient covering to absorb vapors. The outside of the frame also is banked with manure.

Other types of manure-heated hotbeds.—The pit sometimes is dug a foot wider than the frame and is not lined with boards. Portable frames are placed on top of the manure, which is about even with the surface of the ground, and the frames are then banked with manure. This plan requires more manure, although the beds furnish heat for a longer period. The frames settle with the manure, so that the plants are always the same distance from the glass. Another plan often used southward and on poorly drained land is to place frames over manure piles on top of the ground, and in this way dispense with the pit. This requires more manure than either of the other plans described.

Manure from spent hotbeds is very useful for composting plant-growing soil, for placing in the bottom of flats or plant beds, and for hill fertilization of cucurbits.

Flue heated hotbeds.—Systems of flues or air spaces beneath the soil and leading from wood or coal burning furnaces to short chimneys are successfully used by many growers. They are especially popular among growers of sweet potato plants. Such systems often are more economical than manure hotbeds and the

FIG. 10.—Elemental diagram of flue-heated hotbed. Another method is to admit steam as required into the buried tiles.

results, with proper management, are equally satisfactory. Details of construction vary. In general, a furnace or firebox of brick is built at a suitable depth just outside one end of the bed. It should be of good size, at least 2 feet wide, 3 feet high, and 4-6 feet deep, with provision for an ash pit under the grate bars. Two flues are built, one from each corner of the firebox, extending to the other end of the bed, which may be about 30 to 60 feet long. Six-inch vitrified tiles make very satisfactory flues and do not crumble easily from heat. The flues may terminate in chimneys, just outside the corners of the distant end of the bed, or they may be brought to the surface by ells a short distance inside that end. With the latter arrangement a floor is erected in the hotbed with about a foot of air space below it. The hot gasses discharged by the flues enter this space and are returned by the draft of two chimneys, one connected to the air space at each corner of the bed nearest the furnace. Near the furnace the flues should be 2 or 3 feet under the surface, rising gradually to about a foot at the opposite end where they enter the chimney or air space. The arrangement with air space under all the soil provides the most even degree of heat and is used a great deal in producing sweet potato plants in New Jersey. In that system the hot gasses go out through the tile flues and return at a lower temperature through the air space under the floor which is covered with about 5 inches of soil. Soil temperatures may be controlled very accurately by checking the draft at the furnace with a plate of sheet metal and by equalizing or checking the draft from the chimneys with short boards.

Hot water and steam heated hotbeds.—These are the most expensive types of hotbeds. Heat may be supplied from a central boiler that is used to heat greenhouses or from a small boiler set at the end of the bed in a pit of suitable depth to provide good circulation. Piping is arranged so that the circulation starts from one

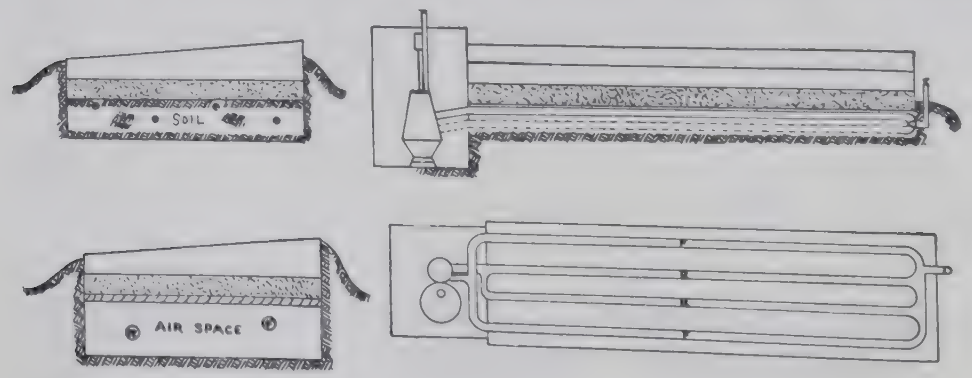


Fig. 11.—Elemental diagram of hotwater-pipe hotbed. Detail is slightly different with steam. Pipes are usually buried, or they may be installed in air space as shown at lower left.

of the upper connections on the boiler and proceeds at least slightly upgrade to a 2-inch header just inside the end of the bed. There the flow is divided between 1¼-inch or larger pipes, 2 feet apart, which extend with a gradual rise to the distant end of the bed. There they enter another header which distributes the circulation into return pipes. These are of the same size as the flow pipes and are located midway between them. Provision for venting air must be made at the high point, preferably at both ends of long headers. The return pipes are laid with a gradual fall, and connect into a third header from which the circulation is returned to the bottom of

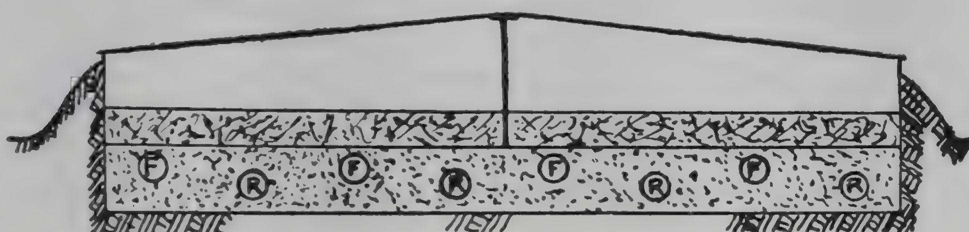


Fig. 12.—Outline cross section of double-width hotwater or steam heated hotbed.

the boiler. In hot water systems an expansion tank must be provided and should be located directly over the boiler to avoid freezing. In the completed system, flow and return pipes alternate at 12-inch intervals throughout the width of the bed and are covered with about a foot of soil. By using a small motor-driven circulator, hot water heated beds may be placed at almost any convenient level and a small bed can be heated from the residence boiler. Farmers' Bulletin No. 1318 may be used as reference for calculation of piping.

A simple type of steam hotbed is constructed by placing parallel lines of common farm drain tile a foot or more deep and about 18 inches apart. Two lines will suffice for a standard six-foot frame. Steam is piped to one end of the drain tiles and is admitted, under the control of valves, as frequently and as long as may be necessary to maintain the desired soil temperature. This system may be used to disinfect the soil by steaming sufficiently to raise the temperature to about 160 degrees Fahrenheit or more; during this process the soil should be covered.

Electrically heated hotbeds.—Under most conditions manure, wood, coal, fuel oil, or natural gas, will furnish heat for the hotbed


Fig. 13.—Elemental diagram of electrically heated hotbed with lead covered flexible heating cable and thermostat.

more cheaply than electricity. However, the electric hotbed with thermostatic control assures the maintenance of minimum temperatures without annoyance. It is especially convenient for small areas. The installation of electric hotbeds is not unusually expensive, nor is it difficult. The heating cables also are useful to provide heat in propagating beds. Instructions for installation are provided by manufacturers of the equipment.

PLANTHOUSES

Advantages of planthouses.—For starting early vegetable plants the greenhouse possesses decided advantages. Heat, moisture, and ventilation are better controlled. The gardener spends much of his time inside the house, and he has abundant opportunity to note every change. If the soil is too dry or the air is too warm, it is detected before injury has been sustained by the plants. Fresh

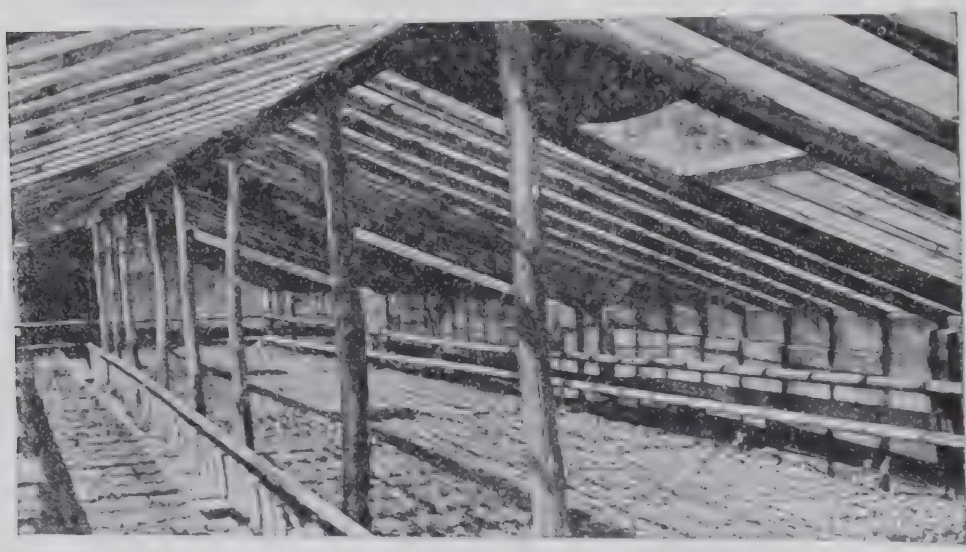


FIG. 14.—Interior of inexpensively constructed plant house. Excavated walk allows head room.

air may be admitted in the severest weather without cold drafts striking the plants. This is difficult in hotbeds. The handling of mats is eliminated. Watering is done from the inside without raising sash. Altogether, much more economical and better control is secured. Many growers build at least part of their sash into planthouses; others build standard types of greenhouse construction. These cost more, but are more weatherproof and permanent than sash houses and are suitable also for vegetable forcing operations. Many growers have found that the cost of fuel and firing to hea

planthouses is less than the expense for providing and handling mats on an equal area of hotbeds. During bad weather, labor often may be employed inside the house.

Uses of planthouses.—Planthouses are especially useful for growing seedlings that are to be transplanted into mild hotbeds or coldframes. Often the houses are warmed three or four weeks before the desired time for transplanting, and are utilized thereafter to produce cabbage, lettuce, celery, tomato, and other seedlings in a continuous succession to fill the coldframes promptly as the hardiest and earliest plants are moved to the field or are sold. Sometimes lettuce, radishes, or rhubarb are forced for late winter or early spring markets.

Construction of small houses.—It is important to choose a site that is protected from prevailing winds and that receives the full benefit of the sun. Details of construction vary with the ideas of the grower, the size of the house, the materials available, and capital, but are relatively unimportant provided that economy in construction and serviceability in operation are secured. Proper provision for ventilation is most essential. The house should be reasonably waterproof and windproof. Sufficient supplies of water must be available. The heating system must be adequate for conditions, and dependable.

Where drainage permits, the walls of a small sash house need not be more than a foot or two high. Then head-room is provided by digging a narrow trench through the center to serve as a walk. Low houses of this type require the smallest amount of materials and are very easy to heat. A very convenient form of larger sash house is

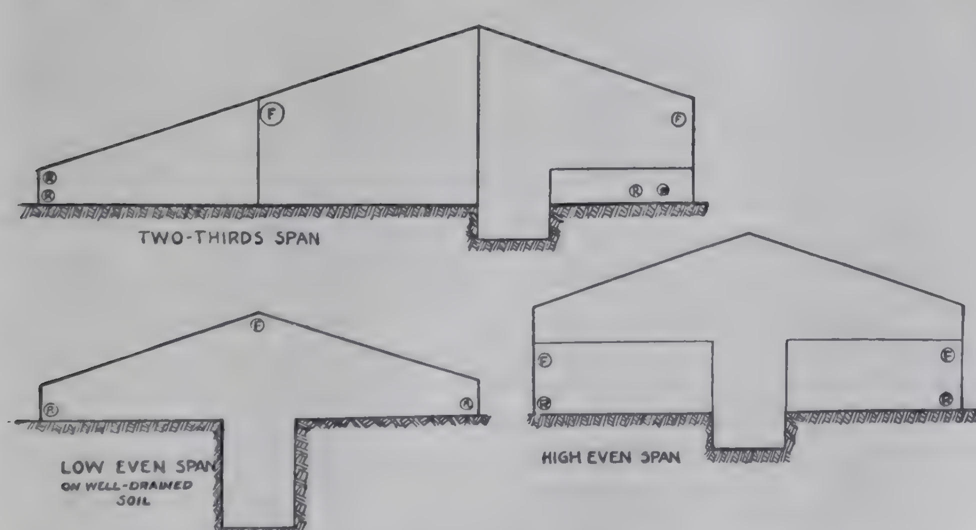


Fig. 15.—Cross section outline of typical sash houses, heated with hotwater or steam. Flues or stoves are sometimes used.

the two-thirds span type with two tiers of standard sash running from a ridge five feet high to a 12-inch plank wall on the south side, and one sash sloping from the ridge to a north wall about 3 feet in height. Full head room for caring for the plants is provided by excavating a narrow path to the depth of a foot. To secure maximum benefit from the morning sun, plant growing structures should be oriented nearly east and west. However, this is not essential.

Many greenhouse manufacturers willingly supply catalogues and other helpful information on the construction of planthouses.

The heating of small houses may be accomplished by means of stoves if the structures are very small. Brick or tile flues hold heat longer and are commonly installed to encircle the house beneath the benches, more or less after the manner suggested for hotbeds. Hot water systems are well adapted to sash houses because only infrequent attention is required. Steam heat also is very satisfactory but will demand more attention at night.

Benches and ground beds.—Soil on raised benches warms more quickly and averages higher in temperature than does the soil of ground beds. As a result seeds germinate quickly and plants grow rapidly, particularly very early in the spring. On the other hand when the weather becomes warm, many kinds of plants will grow equally well or better on ground beds and will require much less watering.

COLDFRAMES

Uses of coldframes.—Coldframes are less expensive to buil and to operate than the plant-growing structures discussed hereto fore, and their total area is much larger. Their usefulness in receiv ing transplants from seedlings started earlier in hotbeds or green houses has been mentioned. Coldframes are used alone on many farms to produce plants that are considerably earlier than can b grown in the open and costs are very low. Because coldframe usually are managed without heat, other than that received from th sun, they are necessarily started later than hotbeds. Coldframe are employed extensively to accustom greenhouse-grown plants t the full effects of sun and wind as preparation for the rigors of th open, and to hold plants until they can be set in the field or sold The use of coldframes in forcing very early spring and late fal crops to partial or full maturity is discussed in Chapter XXV.

Location, water supply, and soil for coldframes.—Becaus the sun is usually the sole source of heat, it is important to locat frames where they will be sheltered from cold winds, or to plant o erect windbreaks for that purpose. Good drainage assures quicke warming of the soil. Unless the plants are to be grown in flats great care should be exercised in selecting and preparing the soi

Suitable soil must be provided if the natural soil is poor or has been removed in grading. Very large quantities of water will be required during warm, breezy days and it is important, therefore, when many sash are used, to have ample supplies of water under pressure with sufficient outlets so that all watering can be done with hose. If the coldframe plat is extensive, sprinkler irrigation may effect a profitable saving in labor and will apply water more evenly than can be done by hand methods.

Construction of coldframes.—First, the area should be graded so that it is even and level. The frames may then be built, or, in the case of portable ones, placed with least labor. Furthermore, a level surface is necessary for even watering whether the plants are grown in flats or ground beds. The frames may be built somewhat as indicated for hotbeds, but the structure is placed entirely on the

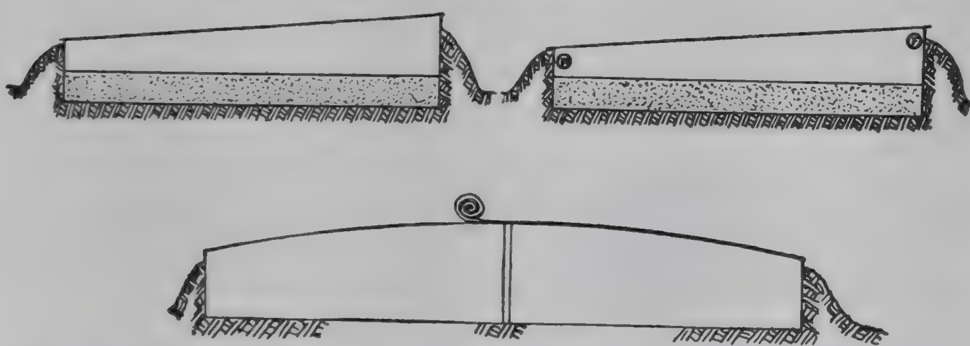


FIG. 16.—Coldframe, coldframe with pipe coil for heating, and muslin covered frame. Any of the forms may be single or double width.

surface of the level ground and no excavation is required. The height of the sides, or, in other words, the depth of the frame, must be determined by the size of the plants to be grown. Ordinarily, a 12-inch board or plank is high enough for the north side and an 8-inch piece for the south side. An additional depth of 2 to 4 inches is an advantage in some lines of work. If flats or plant boxes are to be used in growing cabbage and tomato plants, the frame at the north side should be 16 inches deep and at the south side 10 inches.

The frames may be portable or stationary. The most common plan is to nail the side boards or planks to stakes placed on the outside. The end boards, held in place by cleats or other devices, may be removed and the soil of the frame prepared by cultivating. Crossbars, if used, may be dovetailed into the side boards so they can be removed quickly.

While portable frames are used by many growers, they are not generally popular. Portable frames may be dovetailed at the corners or held together by rods and bolts. They are usually made

in sections to accommodate either two or four 3x6-foot sash. The outside of frames when used in cold weather should be banked with soil, manure, or sod.

Protecting frames from cold.—To conserve the heat necessary to carry plants through cold periods it usually is necessary to cover the glass at night, and during very cold days without sunshine. Sometimes loose hay or straw is used for a covering, but mats generally are preferred. Straw mats may be woven at home with binder twine on a roughly made loom. Burlap mats can be purchased ready-made but many growers make their own from single or double thicknesses of burlap, usually old fertilizer bags that have been washed. After the bags have been sewed together to make the desired size, the mat may be treated as described later.

Or, mats may be dispensed with by running a coil of steam or hotwater pipes around the inside of the walls to provide protection from freezing and to accelerate growth during prolonged cold periods. When such heat is provided, and especially when mats also are used, growth of hardy plants may be nearly as rapid as in hotbeds.

Muslin covered plant beds are the least expensive of the plant-growing structures. They are common in the South, and are useful in the North for starting plants somewhat earlier than they can be grown in the open. They are very useful also in providing overflow

FIG. 17.—Rolling muslin cover on coldframe used for hardening plants started in sash house. The hill gives shelter from cold winds.

space, where plants that have reached nearly full size under glass can be protected from frost until time for planting or selling. When bottom heat is provided by any of the means described for hotbeds, quite satisfactory early plants may be grown under muslin. Considerable light is transmitted through the cloth, which may be rolled partially or fully open on sunny days as temperatures may permit. It has been repeatedly demonstrated that a double covering of good muslin usually will protect plants through a colder night than glass sash without mats. Even a single thickness of muslin will turn a fairly heavy frost. An additional advantage of cloth-covered plant beds is the very small amount of labor required in opening and closing the covers.

The frames usually are constructed with one edge of the cloth nailed in place under lath or strips fastened along the north wall, or the side from which the prevailing winds come. One by two-inch cross bars are sufficiently heavy and the cover is opened or closed by rolling on a pipe run through a hem in the free edge. Or it may be rolled on one by two-inch wooden strips tacked together with the free edge of the cover between them.

Waterproofing covers.—To render muslin covers or burlap for mats more weatherproof and durable they may be placed in a double thickness on a clean floor and sprayed or painted with hot, raw linseed oil. The covers are then rolled together for a time, to permit thorough saturation, and finally are hung to dry. Or the waterproofing process suggested in the next paragraph may be used. Covers are made large to allow for shrinkage.

The directions that follow are from Farmers' Bulletin No. 1157:

"Canvas treated with waterproofing preparations containing certain pigments such as lampblack and the earth pigments (ochre, sienna, and umber) does not lose so much of its strength when exposed to the weather.

"For canvas paulins or large portable covers—

FORMULA 1

Petrolatum (vaseline), dark or amber	pounds	8½
Beeswax, yellow refined	do	1½
Earth pigment, dry (ochre, sienna, or umber)	do	5
Volatile mineral spirits (painters' naphtha)	gallons	5

FORMULA 2

Petroleum asphalt, medium hard	pounds	7½
Petrolatum, dark or amber	do	2½
Lampblack, dry	do	1
Volatile mineral spirits (painters' naphtha)	gallons	5

"The quantities specified are sufficient to treat about 40 square yards of canvas on one side.

"A mixture of 3 gallons of gasoline and 2 gallons of kerosene can be substituted for the volatile mineral spirits, but will evaporate more slowly.

"In the preparation of waterproofing solutions . . . place the specified weights of waterproofing materials in a suitable metal container and melt slowly and carefully at as low a temperature as possible, with constant stirring. Then

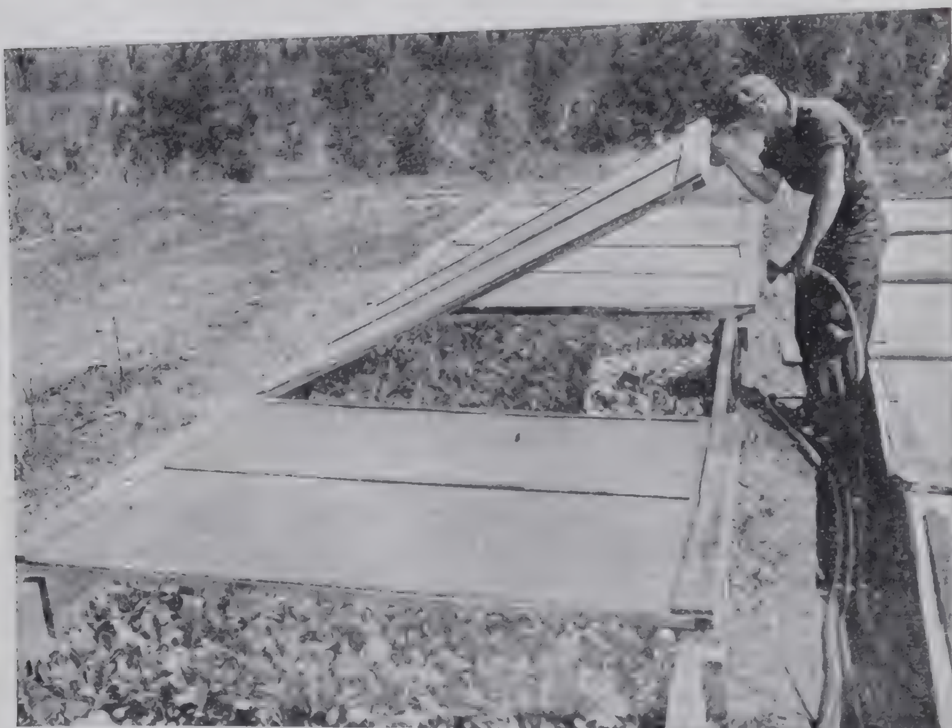


FIG. 18.—Cloth-covered sash, under many conditions, are a useful addition to the plant growing equipment.

remove to a place where there is good ventilation and no fire or open flame and pour the melted material into the solvent while stirring. When a pigment is used, thin the pigment in a separate container by mixing with it small additions of the liquid, and when the pigment mixture is sufficiently thinned strain it through fine-mesh wire screen or several thicknesses of cheesecloth into the waterproofing liquid.

"When the waterproofing material settles to the bottom of the container or thickens, it will be necessary to warm the mixture just before applying it to the canvas. This must be done in the open air by placing the container in a tub or can of hot water. Be sure that the container is open, and *never place it over or near a flame.*

"The mixture must be thoroughly stirred before and during application, in order to keep the undissolved material in suspension. These preparations may be applied to the canvas by means of a paint brush or by spraying . . . with a pressure of at least 50 pounds . . . one coat applied to one side of the canvas usually is sufficient."

SOIL SUPPLY

The ideal soil.—Soils for growing early vegetable plants should absorb water readily and dry quickly at the surface, but they should not dry out too easily. A sandy loam well supplied with organic matter furnishes ideal conditions. It should be in a well balanced state of fertility, free from notable deficiencies or excesses. Suitable soil for plant growing sometimes may be found in garden or field but it usually must be prepared for the purpose. In any case, care must be exercised to provide soil that is free from troublesome diseases. Sand culture of seedlings is outlined on page 58.

Preparing soil for plant growing.—One method is to select a favorable area, lime it if necessary, broadcast superphosphate, and apply manure to a depth of four or five inches. The soil is plowed and harrowed several times during the summer and stored before fall rains begin. If stable manure is not available two or three green manure crops may be grown and worked into the soil in the course of the summer. Complete fertilizer should be applied for the soil improving crops.

A more common and usually convenient method is to compost soil of good texture, or sods, in alternate layers with manure. If heavy soils are used, layers of coarse sand should be included in

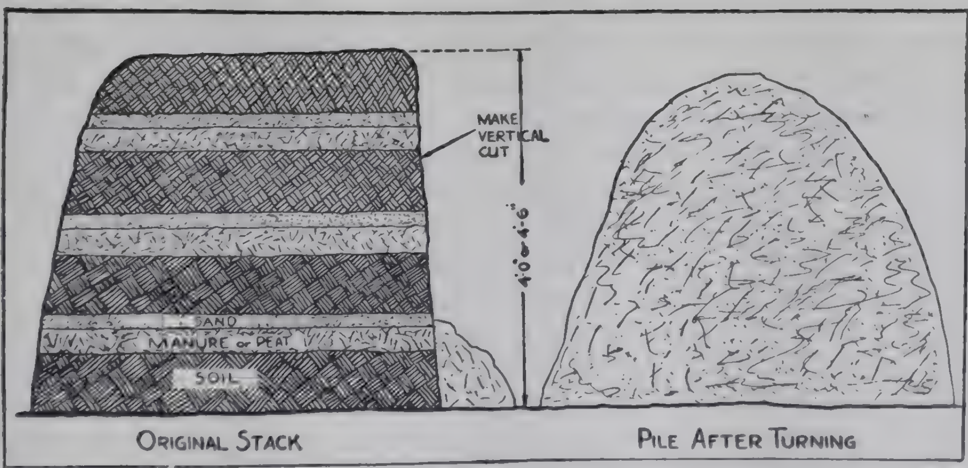


Fig. 19.—Composting soil for plant growing. Proportions vary with conditions. Usually a suitable amount of lime or pulverized limestone, and bone meal or complete fertilizer should be included.

rotation with the other materials. Generally the layers are four to six inches deep with lime at the required rate raked into each layer of soil. Superphosphate or bone meal, one or two pounds to 50 square feet, is scattered over the manure. With very strawy manure or other highly carbonaceous materials, decay will be more

rapid if nitrogen is included in each layer at the rate of about a pound of the common nitrogen carriers to 50 square feet of area. Water should be applied if necessary to keep the moisture supply near the level known to be favorable for plant growth.

When the fibrous material in the stack is decomposed sufficiently to break easily the pile should be cut down in vertical slices and shoveled over. One or more turnings at suitable intervals will assure a fine, well-mixed soil ready for storage, or the pile as it stands may be protected by a temporary roof. The essential point is to have an ample supply of good soil in workable condition whenever it is needed. It is a serious error of management to be in a position where poorly prepared, wet, or frozen soil must be used.

Soil disinfection.—When fresh soil can be used, and is known to be free from soil-borne diseases of vegetable crops, disinfection is not essential but may be desirable. A common method is to drench the freshly spaded soil with a solution of one part of 40 per cent formaldehyde solution in 50 parts of water. Application, which should be at the rate of one-half gallon to the square foot, may be made with a sprinkling can, or, on larger areas, with hose and nozzle supplied from a power sprayer.

Sometimes an easier method is to add one gallon of formaldehyde to five gallons of water and apply the six gallons to 100 square feet of area. Then the soil is spaded and enough water is applied to wet the bed to the bottom. The next step is to cover the area for 12 to 24 hours with canvas, paper, or any material that will help retain the gas. The final step is aeration, a process that is promoted by spading the soil every few days. Seeds or plants may be planted after 14 days if the temperature has been above 60° F.; below this temperature, a longer time must be allowed, particularly with crucifers. Formaldehyde disinfection as described cannot be managed in a house or bed partially occupied by growing plants.

Formaldehyde dusts are convenient for treating small amounts of soil and small vacant areas in houses or frames where plants are growing. The dust should be raked into the beds, or for flats it should be mixed with the soil, at the rate recommended by the manufacturers, usually one-half pound for each bushel of soil. Seeds can be planted immediately, except on very sandy soils, if they are kept well watered for a few days. But it is safer to wait 48 hours. In some soils plants may be transplanted soon after formaldehyde dust treatment but injury may follow within several days or more, especially if the soil is low in organic matter.

Chloropicrin, tear gas, is relatively new as a soil fumigant.

Steam is usually employed wherever it is available under pressure. Typical devices are (1) chests or large tight boxes, in which filled flats or boxes are stacked with spacers; (2) portable inverted

pans for use on beds or benches; (3) portable or permanent perforated pipes, or tile, buried a foot in the soil and about 18 inches apart; and (4) perforated pipes on the bottom of old steel truck bodies, open-top boxes, or shallow pits of concrete, to sterilize batches of soil for filling flats or beds.

To retain heat and promote uniform temperatures, the surface should be covered during the steaming process. Specially treated impervious fabrics are best, but tarpaulins, paper, or other covers are a great aid. It is a common practice to continue steaming until a small potato placed in any part of the soil would be cooked. Longer steaming is unnecessary and is detrimental to the condition of the soil. A temperature of 160 degrees for two hours is generally sufficient, 140 degrees will kill nematodes, Fusaria may require 180 degrees.

Where rates are very favorable, electricity may be used as the source of heat for disinfecting, or pasteurizing the soil.

Thorough disinfection will eliminate soil-borne disease organisms, and most methods will also kill weed seeds, but it is not in itself assurance against diseases. Recontamination may occur from particles of contaminated soil on shoes, tools, or plant boxes. Disinfection only provides a clean start. The principles of good management must be observed in watering, ventilating, and maintaining temperatures.

CONTAINERS FOR PLANT GROWING

Flats or plant boxes are often used in greenhouses and they are convenient in many ways when starting plants in hotbeds and coldframes. Many gardeners use them extensively. The advantages of flats for many conditions may be enumerated as follows: (1) They make it possible to do all the work of seed sowing and transplanting in warm, comfortable rooms provided with tables or benches of convenient height. (2) Sowing or transplanting may be continued whatever the character of the weather—a matter of economy in the use of labor. (3) Growth of plants may be checked more readily in flats during periods of warm, showery weather or when unfavorable weather delays planting in the field. (4) Each flat contains a uniform number of plants, a great advantage in making sales. (5) The buyer may receive the plants in the flats and transport them and keep them in perfect condition. (6) Flats may be hauled to the field ahead of the planting crew and distributed at convenient intervals. (7) Plants grown in flats are easily removed for transplanting with a large amount of soil and small disturbance of the roots. However, a great many people grow part or all of their plants without flats, often at a lower cost, and have developed procedures which produce equally good results. The best method

is determined by conditions. Celery plants are particularly responsive to the more even moisture supplies of deep benches or ground beds.

To avoid waste of space the flats used by a grower should be standardized at any convenient size that fits the plant beds. Flats 16 by 22 inches and 13 by 18 inches outside dimensions, are popular in commercial operations. They hold 100 to 150 plants at the usual spacings. Smaller flats that contain 25 to 50 plants are convenient for the retail plant business. Inside depth of two inches is ample for most purposes. Deeper flats require much more soil and are heavier to handle. If new lumber, carefully cut to the right length, width, and thickness, is provided for the ends and sides, thin lumber from second-hand boxes, or even the middles of staves from second-hand potato barrels, may be employed for the bottoms with much economy in many localities. Wire bottoms of hardware cloth are economical and durable. Because ordinary box nails often rust away before the wood decays, cement-coated nails should be used.

Pots and bands are used to a considerable extent in growing large tomato plants and eggplant plants, and are practically a necessity for successful transplanting of melon and cucumber plants, the root systems of which are both limited and very susceptible to injury. Earthen pots are very satisfactory, except for their costliness and the labor of handling them. They dry out very rapidly unless they are plunged into the soil and hold only about half as much soil as a cube of the same diameter. Paper pots are inexpensive and have produced good results in some cases; in others, the plants have become stunted and yellow, perhaps because bacteria in decomposing the paper have robbed the soil of nitrogen needed by the plants. Wood veneer bands, which are received flat and marked ready to fold into squares of the desired size, are among the most popular and widely used, inexpensive plant containers (Fig. 134, p. 453). They are durable and in transplanting may be removed without disturbance to the plants. Where large numbers of containers are not required, quart berry boxes, empty tin cans, or even inverted sods are often used.

SOWING

When to sow.—Proper dates for sowing different vegetables under glass vary greatly with circumstances. Factors to be considered are: the time when the plants are to be transplanted into the open ground; whether the plants are to be grown ready for the field without transplanting, or with one or even two transplantings; the warmth of the plant-growing structures, and the methods and practices of the individual grower in regulating temperature, moisture, and ventilation. Obviously seed sowing dates may vary considerably

among growers of the same crop in a community. The following seed-sowing schedule is based on average plant-growing equipment and practices and is included, therefore, only as a general guide:

SEED SOWING SCHEDULE FOR PLANT GROWING

For localities where hardy plants can be set outdoors about the middle of April and tender plants late in May. The number of transplantings refers to shifts under glass and does not include transplanting into the field.

February 1-15

Early cabbage, lettuce, and parsley to transplant once.
Onions thinly, not to be transplanted.

February 16-28

Cabbage, cauliflower, broccoli, earliest celery to transplant once.
Tomatoes to transplant twice.
Beets thinly, not to be transplanted.

March 1-15

Tomatoes and eggplants to be transplanted once or twice.
Peppers and celery to be transplanted once.
Cabbage and celery thinly, not to be transplanted.

March 16-31

Tomatoes, eggplants, peppers, celery to be transplanted once.
Cabbage, celery, and peppers thinly not to be transplanted.

April 15-30

Celery, fall cabbage, cauliflower, broccoli, thinly in outdoor beds, not to be transplanted.

May 1-15

Muskmelons and cucumbers in pots or bands, under glass, not to be transplanted.
Late celery, cabbage, cauliflower, broccoli, thinly in outdoor beds, not to be transplanted.

May 16-31

Late cauliflower, broccoli, and early strains of late cabbage, thinly in outdoor beds, not to be transplanted.

A table of the amounts of seed usually required to produce a certain number of plants will be found in the Appendix (p. 506).

Preparing the soil.—To secure a high percentage and an even rate of germination the soil must be fine, moist, and firm. When the soil in ground beds or benches is dry to a considerable depth, as often occurs in vacant greenhouses, it should be watered very thoroughly. As soon as the surface few inches of soil are dry enough to work it may be raked smooth and level. Soil for flats may or may not require screening and, if dry, can be moistened evenly by sprinkling the pile as the soil is being turned. In filling flats or plant boxes the soil must be pressed firmly in the corners and along the sides to

prevent excessive drying and settling at these places. The surface is leveled with a straightedge.

Sowing.—Broadcasting to produce seedlings for transplanting often is practiced but is generally less satisfactory than sowing in rows. Air circulation is not so good, the plants dry less quickly in the morning and after watering, and conditions are favorable for

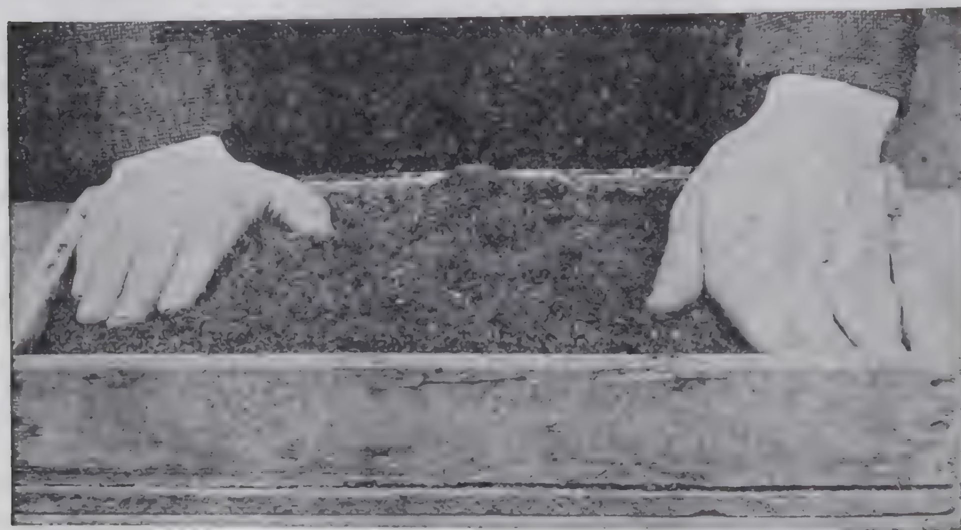


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FIG. 20.—In filling flats, the soil should be firmed in the corners.

damping-off. Plants in rows are lifted more easily in good arrangement for rapid transplanting and weeds may be worked out more easily. Thick broadcasting, however, is useful in producing a great number of seedlings in a small area when they are to be pricked out and transplanted promptly, as often is done with lettuce. By broadcasting thinly to allow considerable space for each seedling, very stocky plants, comparable with those secured by transplanting, may be produced.

Rows or tiny furrows to receive the seeds may be opened with a U-shaped or V-shaped straightedge and are about ⅛-inch in depth for celery, ¼-inch for cabbage and tomato, and ⅜-inch for onions and beets. For fairly prompt transplanting, spaces 1½ to 2 inches between the rows are sufficient, but 3 to 4 inches or more will be needed if the seedlings are to be grown to some size before transplanting, as is often done with tomatoes and peppers.

When the seedlings are to be grown to full size, ready for the field, in the original rows, 6 or more inches of space should be provided between rows to permit stocky development. For this pur-

pose it is a special advantage to make furrows with U-shaped bottoms so that the seedlings will be distributed somewhat.

Distribution of seeds in the row ranges from only a few to the inch, when the plants are to be grown for some time without transplanting, to as many as 10 or 20 to the inch when the seedlings are to be shifted very promptly. More than 8 or 10 seedlings to the inch, however, will cause crowding except with lettuce and celery transplanted at a very early stage.

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Fig. 21.—Making U-shaped furrows for small seeds. Distribution of seeds is better than in V-shaped marks.

A convenient method of sowing seeds rapidly and evenly is to distribute them, with a vibratory motion, from the mouth of a squarely cut envelope or a flat tobacco tin. Small mechanical seeders are satisfactory wherever space permits their use.

The seeds may be covered in the furrows by a convenient motion of the fingers, or with the aid of wooden strips. An excellent means of covering is to apply screened dry sand through the hole in the bottom of a small clay pot or through a large nail hole in a tin can Fine soil or sand may be sifted over broadcasted seeds and leveled

with a small straightedge. Sand covering permits the seedlings to push through with minimum effort, drys quickly, and is thus of some effect in preventing damping-off. Sand falls away from the stems during transplanting which permits the detection and discarding of diseased seedlings.

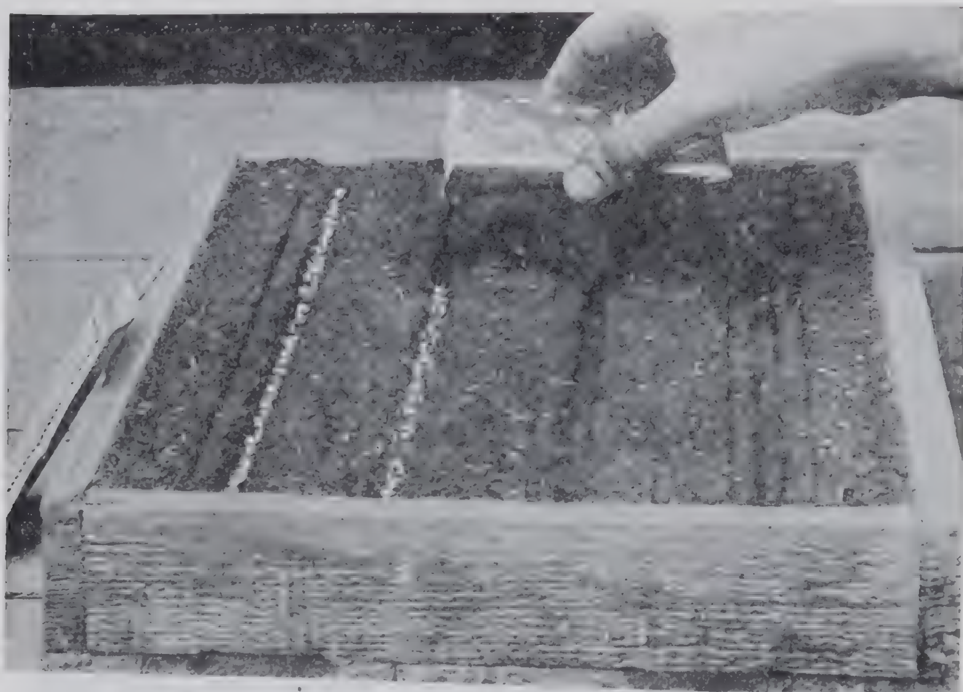

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FIG. 22.—Sowing from an envelope. Some growers prefer a tobacco tin suitably bent at the open end.

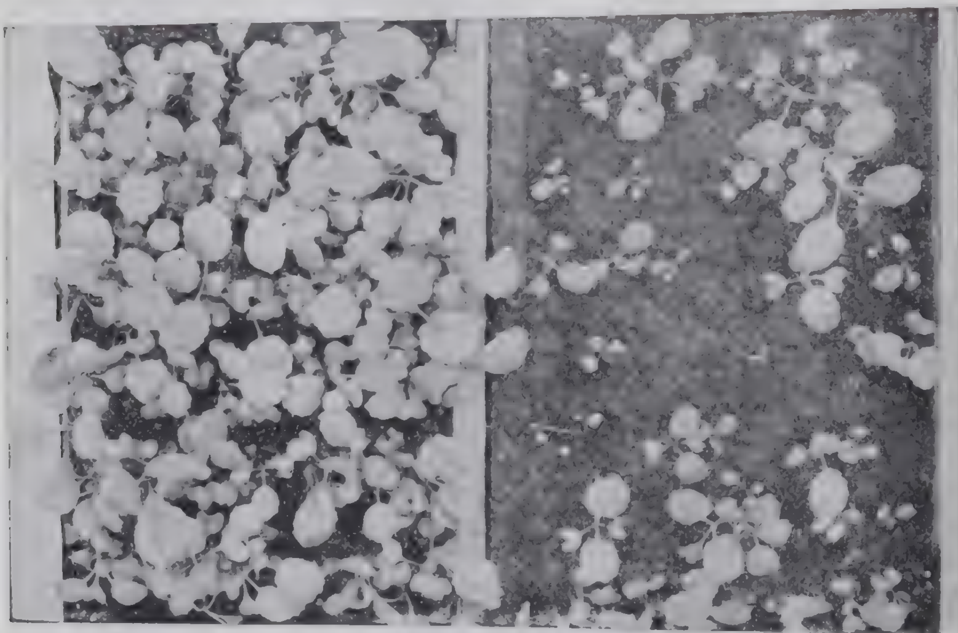
Care after sowing.—Watering immediately after sowing may be omitted if the seeds have not been treated with chemicals and if the soil is very moist and has been firmed well. Warm water is preferable but not essential and should be distributed through a fine sprinkler to avoid packing the soil or washing away the covering. A common practice with celery and other fine seeds is to cover the soil with a single thickness of burlap and then water through that. If fertilizer bags are to be used they must be very thoroughly washed and repeatedly rinsed to avoid injury to germination. Ideal moisture conditions may be maintained more easily if the burlap is left over the seeds until sprouts begin to appear above ground. Newspapers are also commonly employed to preserve even supplies of moisture, especially with late spring sowings under glass. Temperatures are discussed later.

Damping-off.—Decay or rotting of the stems of young plants near the surface of the soil is known familiarly as damping-off. The organisms (p. 181) may attack the germinating seeds and cause serious losses before the tiny plants emerge. Damping-off sometimes becomes a rampant and disastrous malady when conditions favor its development. Careful plant growers, however, seldom suffer extensive losses.

Appropriate seed treatments (p. 22), use of uncontaminated soil of a porous nature, fairly water tight—not leaky—sash or houses, prudent watering and ventilating, and proper regulation of temperatures ordinarily will keep damping-off in check. Nevertheless, in spite of all precautions and most often during prolonged cloudy weather, epidemics sometimes develop.

FIG. 23.—Covering seeds with clean sand running from hole in can.

A recently described practice that has proved very helpful is to spray thoroughly with red copper oxide at the rate of one pound in 50 gallons of water, or one ounce in three gallons. Under troublesome conditions it may be advisable to spray the bare soil after sowing and to repeat the application at weekly or slightly longer intervals until the plants are removed to the field. Red copper oxide does not go into solution in the sprayer tank and tends to



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Treated Untreated

FIG. 24.—Effect of treating cabbage seed with Semesan. Zinc oxide also is effective.

settle rapidly. Hence, continuous and vigorous agitation of the spray mixture is essential to maintain an even suspension. If red copper oxide for spraying is used in a prepared form which includes a spreading agent, the manufacturer's directions should be followed. Semesan may be used in the same manner with celery, onion, and cabbage plants.

Copper carbonate dust, at the rate of two pounds in 50 gallons of water or one and one-half ounces per gallon, is used sometimes as a soil application in combating damping-off of beet, tomato, and other plants.

Fairly effective partial disinfection of the soil after sowing seeds of cabbage, cauliflower, other crucifers, and tomatoes may be accomplished by applying a solution of one ounce of corrosive sublimate in 15 gallons of water or a one to 2000 solution prepared from the common tablets. About a pint of the solution is sprinkled to the

square foot of soil or a gallon to 50 feet of row immediately after planting. Thorough watering should follow. If necessary, the same solution may be applied around the lower portions of the stems but injury may occur if the tops are wetted.

TRANSPLANTING

Reasons for transplanting.—The most important reason for transplanting under glass is to provide the young plants at all times with sufficient space for stocky development and to accomplish this with economy of space. For example, based on about the number of plants required to plant an acre, one or two sash will accommodate 10,000 to 15,000 young seedlings of cabbage. When these are transplanted approximately one and one-half inches apart or slightly wider, 15 or 20 sash will be filled. Three thousand especially fine, large tomato plants may be wanted about May 20. The space in one sash will grow the seedlings from March 1 to 20. When transplanted about the latter date, two by two inches apart, five sash will be needed to accommodate them until the middle of April or a little later. Then the additional space released by field planting of the cabbage will permit final transplanting of the tomatoes, about four or five inches apart. Thereafter 20 or 25 sash will be required until the plants are set in the field.

A secondary reason for transplanting is to develop a comparatively restricted and well-branched root system that will make it possible to re-establish the plant in the garden or field without serious check in growth. Breaking and shortening of roots, incidental to transplanting under glass, fulfill the purposes of pruning the roots. A form of root pruning known as "blocking" (p. 56) serves much the same purpose, in regulating root development, as a second transplanting where the plants have been liberally spaced in the first place.

Procedure in transplanting.—Most growers begin transplanting when the first true leaves are forming, usually two to three weeks after sowing, although some prefer to begin when the plants are quite small. If many plants are to be handled, the work should be started promptly in order to complete the operation before they become spindly.

If flats are used, holes for the plants may be made with the aid of a dibbling board as illustrated. When in use the board should be held firmly in place with one hand while the holes are punched with the dibber in the other. If the soil is in proper condition and the board and dibber are used skillfully, every hole will remain open when the board is removed. With soils of fine, sandy texture the holes may be made with a spotting board which contains properly

spaced, sharply tapered pegs to mark the entire flat at one operation.

When transplanting into ground beds or wide benches it is a common practice for the operator to work on one or more wide boards to prevent packing or disturbing the soil. One edge of the board may be notched at the correct intervals for spacing the plants. Holes can be opened with a dibber, or a V-shaped straight edge may be used to form narrow furrows in which the plants are placed and fastened.

Regardless of the method of transplanting it is important to water the seedlings about 24 hours before they will be needed, so that the tops will be dry and the roots can be removed without serious mutilation. The plants should be handled carefully and kept in orderly arrangement to save time in dropping. The flat which

FIG. 25.—Dibbling holes for transplanting in flats.

has been previously dibbled is placed lengthwise on the bench or the table. A bunch of plants is held in position in the left hand near the holes while the other hand drops a good plant into each hole, beginning at the left end of the far row and leaning it against the side of the hole opposite from the worker. The plants are dropped in the same manner in each row of holes, all the plants leaning in the same direction. The observance of these details is of importance for speedy work. Young people soon learn to drop the plants very rapidly, but it is better to have experienced workmen set them. This operation may be done speedily with thumbs and fingers or with the index finger of one hand and a small dibber in the other. Many gardeners make the hole with a small dibber, drop the plant and secure it at once. This is unquestionably the best plan when plants are three or more inches high, but the dibbling or spotting board

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Fig. 26.—Plants start better when the soil is firmly pressed to the roots.

method described is much better for small plants or when a large force of unskilled laborers is at work; it insures straight rows and a uniform number of plants in every flat, or row.

Care after transplanting.—If the soil was made sufficiently moist before planting, little or no water may be needed immediately afterward. The plants should be examined every day, late in the spring twice a day—and watered whenever necessary. Until the plants are established, there should not be too free ventilation, and shading, by placing mats or burlap over the sash, may be desirable. Seedlings planted in coldframes during the early spring may not need ventilation for a week or more. Undesirable cold

drafts over the young plants can be avoided by opening the sash on the side of the structure opposite the prevailing wind.

Blocking is the process of cutting through the soil between the rows of plants so that the longer roots are pruned and each plant must develop many root branches within its own little square. Blocking is especially applicable to the growing of large, strong tomato, eggplant, and pepper plants when spaced 4 or preferably more inches apart each way. Blocking may be done with any heavy knife, but more conveniently with a wide-bladed hoe straightened out, or with a homemade, thin-bladed blocking tool about 10 inches wide. The usual time for blocking is when the plants are about half grown, just before the foliage becomes so large that it will interfere with the operation. Liberal watering will be required immediately after blocking to prevent serious wilting. After blocking, the comparatively undisturbed smaller plants gain in size relatively more than the more severely checked larger plants, with the result that a more uniform lot is produced. On account of their unusually well developed root systems, blocked plants may be lifted with very little disturbance by means of a flat spade pushed under the compost in which they have grown.

GENERAL CARE OF PLANTS

Temperatures.—In hotbeds, sowing should be delayed until the greatest heat has passed and the temperature of the manure has fallen to about 85 degrees Fahrenheit. The warm-season plants, tomato, eggplant, and pepper, require minimum air temperatures of 55 to 60 degrees at night and 70 to 75 degrees during the day for their best development. Cabbage and other cool season crops thrive with night temperatures of 50 to 55 degrees and day temperatures of 60 to 65 degrees. Temperatures 10 or 15 degrees higher than those suggested may be useful in hastening germination or rooting of new transplants and are not harmful on sunny days with appropriate control of ventilation and moisture. Skillful management of temperatures is a major factor in regulating growth. Proper temperatures must be provided to produce the best plants.

Watering.—Skilful watering is the other major means of regulating the rate and character of growth made by plants under glass. Over-watering, particularly in connection with high average temperatures, results in tall, soft, leggy plants that are difficult to transplant and extremely susceptible to disease, injury from sun, wind, cold, or handling. Underwatering favors the development of "hard" plants that do not start readily into rapid new growth.

Watering should be accomplished in the morning and on sunshiny days if possible. Then the plants have time to dry before

night, a most important factor in combating damping-off. However, it is better to water late in the day than to allow the plants to suffer severely from lack of moisture. It is important to water thoroughly rather than too frequently. Penetration of water into dry soil may be ascertained by digging between plants.

The highly successful producer of stocky, uniform plants pays extremely close attention to changing water requirements and guides himself by continual observation of the responses secured.

Ventilation.—On warm days and during hours of bright sunshine, ventilation may be required to reduce temperatures. Ventilation is important also, at times, to rid the structure and the plants of the moisture which often condenses on cloudy, humid days and muggy nights. As a rule, some fresh air should be admitted every day, only a little at first and more after the plants have become well established. The amount of ventilation may be increased as the season advances and the plants become stronger. Very free ventilation is usually accorded to induce firm growth as the plants approach full size. It is bad management, however, to depress temperatures by an unnecessary degree of ventilation at times when growth is needed.

Hardening is the firming of the tissues in order that the plants will be able to endure the hardships of transplanting and of open-ground conditions, such as freezing, hard drying winds, or hot sunshine, any of which may damage or destroy very soft, tender plants.

The principal means of hardening plants are to water sparingly and provide increased ventilation. Lowering the temperature also retards growth and aids in the hardening process. By managing watering and ventilation to best advantage it is unnecessary to incur

FIG. 27.—Early cabbage plants ready for the field.

serious risks, in hardening plants, by exposure to the possibilities of dangerously low night temperatures. When hardening is begun, no more water should be used than is necessary to prevent serious wilting. Air is admitted more freely from day to day. At the end of three or four days the sash may be removed entirely during the day, and the frames closed late in the evening and opened earlier than usual the next morning. Matting is not practiced after a few days more of such treatment and, finally, no protection of any kind may be required day or night. This general plan of hardening is primarily for the more hardy plants, such as cabbage and lettuce. Tomatoes, peppers, and eggplants must be handled less severely. Very free air circulation on days of warm, drying winds is especially effective in hardening both tender and hardy plants.

Although material resistance to frost cannot be developed in the warm-season plants it may be just as important to prepare them to withstand possible burning sunshine, hot winds, and dry soil at their planting season as it is to harden the cool-season plants as protection against freezing six weeks earlier.

Celery plants may be hardened to survive severe frosts but it is important to accomplish this by regulation of moisture and exposure to the full effects of the air. Long-continued temperatures below 50 degrees Fahrenheit, in growing celery plants, are very likely to be followed by the development of many premature seed stalks. Coldframes are unsuitable for celery plants until the weather becomes fairly warm.

Duration and degree of hardening should be no greater than necessary to provide reasonable assurance of high survival under the conditions to be expected at the time of transplanting. For example, severely hardened cabbage plants of a deep purplish or reddish color will endure temperatures 10 to 15 or more degrees below freezing, but they are very slow to start into active growth. That is the principal objection to many so-called frost-proof plants. In comparison, moderately hardened cabbage plants are quite resistant to frost and develop as rapidly as growing conditions permit. Extremely hardened tomato plants often fail entirely to make the strong early growth necessary to produce a satisfactory crop. Skilful growers have demonstrated repeatedly that relatively succulent, but firm, stocky, actively growing plants almost invariably produce earlier and larger crops when transplanted under favorable conditions, particularly when timely showers or watering prevent wilting. It is a matter of wise discretion, in hardening plants, to balance the probabilities of good survival and slow growth with the possibilities of poor survival and rapid growth.

Sand culture of seedlings.—Production of seedlings in clean sand with the addition of a nutrient solution usually produces more

disease-free seedlings than in soil. The root systems are generally better developed and suffer less injury in transplanting. Rate of development of the young plants can be controlled more exactly and they may remain longer in suitable condition for transplanting. One application of the nutrient solution is ordinarily sufficient.

The sand should be neither very coarse nor very fine, not subject to crusting or baking, and as free as possible from silt, loam or organic matter. Directions that follow are quoted from Conn. Bul. 380.

"Wash the sand in several changes of hot water (160°F. or above) until the water remains practically clean after stirring. Place the sand in *clean* boxes or flats. . . . Level off the surface to about 2 inches or more in depth.

"For each square foot of sand surface, dissolve about one-half teaspoonful of saltpeter (potassium nitrate) in about one-quarter-pint of water and sprinkle over the sand. . . . For larger surfaces add 1 ounce of saltpeter in 3 pints of water for each 10 square feet.

"Drill or sow seeds and cover with the same washed sand. Keep surface of sand moist by occasional watering until the seedlings are grown.

"Avoid contamination of the sand by using clean water in watering. Do not add soil to the culture under any conditions. If seeds need more covering after they have sprouted, use only clean, washed sand for this purpose."

Insects and diseases in the plant bed.—Spraying or dusting in many cases should begin at an early stage. Celery blights and the foliage diseases of tomatoes often become established and widely disseminated among the plants before they go to the field. Damping-off is discussed earlier in this Chapter. Aphids or plant lice may demand attention. Flea-beetles, which sometimes cause serious injury to tomatoes and eggplants in the plant bed, are quite certain to attack the young plants in the field. Much less labor and material will be required to apply a protective covering while the plants remain in the relatively small areas of the beds. For specific recommendations refer to Chapter X and to the topics Plant growing, Insects, and Diseases in the chapters on the culture of the several groups of crops.

V

MANAGEMENT

WHERE multitudinous activities and perhaps many individuals are involved, effective control and direction can be exercised only through efficient organization of the business. On the vegetable farm, this implies bringing the thousand varied activities of the year into systematic connection with one another. Each individual operation and worker must contribute in an adequate and orderly manner to the advancement of the whole enterprise. Good management begins with thinking through, systematizing, and organizing the farm business.

In a sense, organization is consolidated and applied experience. Out of the training and lessons of the past a business organism is developed which may be expected to carry on into the future with some assurance of success. Thus organization safeguards against mistakes, oversight, neglect, procrastination, miscarriage of plans; in all, it goes a long way to insure against failure.

Planning plantings.—Maps of the farm are essential, either simple home-made sketches, or better ones that can be printed at slight expense from a negative of the original tracing over common blue print paper. For convenient reference, the maps are filed flat in a drawer, where they are instantly accessible and provide the heart of the system of plans and records. Thus the sheet on top carries pencil notes that indicate exactly where and when each planting is to be made. As field work proceeds the penciled memoranda are erased and records of liming, fertilizing, and plantings are entered in ink. By the end of the season the sheet of plans has been converted into a page of permanent records. With such record sheets of past years arranged consecutively in a desk drawer the grower can ascertain in a moment, without recourse to notebooks or filing cases, the whole story of any part of any field. During the rush of the planting season, the advance of the ink and retreat of the pencil provide a veritable "plan of battle" that helps keep one to his objectives.

What crops and acreages to plant must be determined in accordance with opportunities for marketing, adaptations of soil and climate, equipment, availability of capital and labor, and the grower's training and experience. Sound plans evolve through careful weighing of these and other factors that may appear in the balance either for or against success of apparently desirable undertakings.

Selection of equipment that will permit economical and efficient production is especially important. On the one hand, it is possible to invest too much in machinery for the size of the operation; on the other it is a serious handicap to be inadequately equipped. In particular, power should be available to complete work promptly. Delay increases costs and causes losses. Implements, for efficient operation, must conform in type and capacity to the size of the power units, whether animals or engines. Horses or mules may be more economical where feed can be purchased or produced cheaply. A

FIG. 28.—Yearly maps of the farm are almost a necessity in making plans and in recording soil analyses, soil treatments and plantings.

great many growers, however, who must purchase feed have reduced the number of work animals and increased the use of tractors. A combination of tractor power and horse power is most efficient and economical under many circumstances. On the other hand, many vegetable farms are operated entirely without work animals and at very low acre-cost.

A great advantage with tractors, especially in vegetable gardening where timeliness is so important, is their capacity to work 24 hours a day when required, whereas animals may be soft when needed most, such as early in the spring or after a long period of inclement weather.

The smaller garden tractors are really suitable only for seeding and cultivating and, under the best conditions, for shallow plowing. The larger garden tractors, that draw riding or sulky type implements, will manage plowing in limited areas.

The most generally useful tractors for vegetable growers are the so-called general purpose or row-crop machines with single or dual front wheel and with rear wheels adjustable to row widths. These can be used to plow, harrow, cultivate, and pull sprayers or wagons as required. They may be worked successfully in very narrow rows.

FIG. 29.—Tractors used on an extensive vegetable farm, types for efficiency in every operation.

Rubber tires are preferred by many tractor operators, particularly on sandy soils. Their use results in greater tractive efficiency under certain conditions. It is an especial advantage to use rubber in front on general purpose tractors, even when spade lugs may be retained in the rear to keep down cost or to provide traction through wet spots or during rainy periods.

The track-laying tractors are very efficient for heavy duty plowing and discing and for pulling all kinds of loads wherever tractive

conditions are unfavorable. With treads of suitable gauge such tractors sometimes are used for row work.

Tillage tools, planters, sprayers, and other kinds of equipment are considered in succeeding chapters.

Arrangement of fields.—Convenience and economy should be considered carefully in laying out fields and roads. The best arrangement varies with kinds of crops, acreage, machinery, and topography; but the matter is not to be overlooked by the seeker after lower costs. In general, long rows are more economical to farm, but they must not be too long for convenience in planting and especially in harvesting certain crops.

The establishment of sets of fields of nearly uniform acreage is an advantage in making rotations. In some cases uniform length is desirable for interchangeability of irrigation equipment, perhaps from early crops to later ones.

The grower should calculate the fractional part of an acre that is contained in a 10 or 12 foot strip of his fields. Then, as the work progresses, he can check immediately the rates per acre of fertilizing, liming, seeding, as well as the labor costs of different operations, and the yields. Strips 10 feet wide and 109, 218, 436, and 872 feet long contain $\frac{1}{40}$, $\frac{1}{20}$, $\frac{1}{10}$, and $\frac{1}{5}$ of an acre, respectively. An acre contains 43,560 square feet.

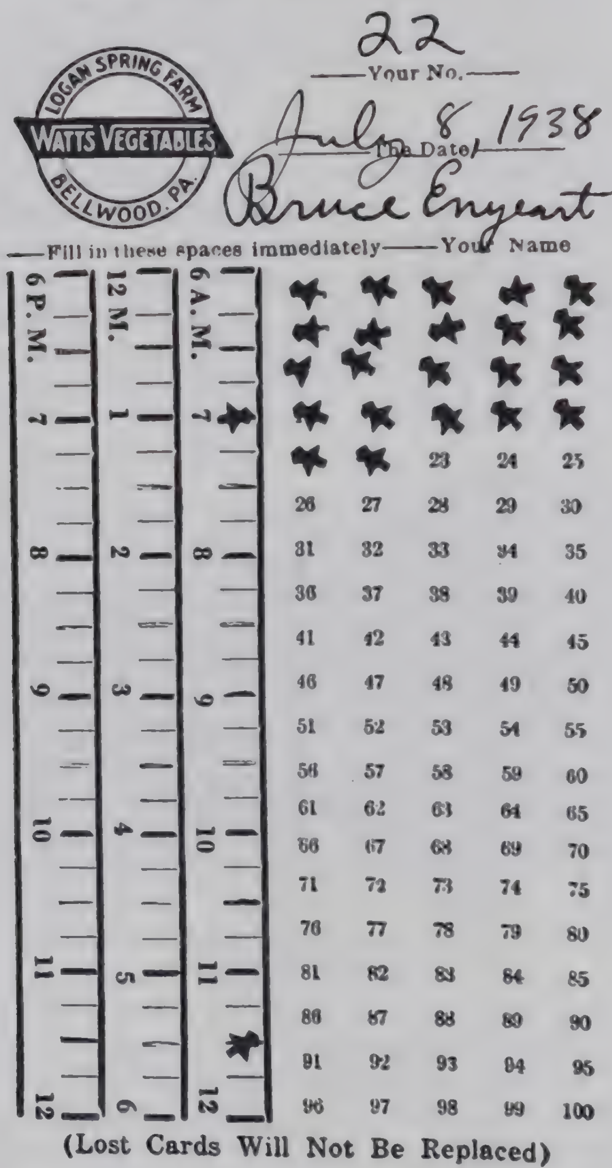
Soil management and fertilization.—The alert manager constantly appraises soil conditions. He often uses a test kit, and never plants a sensitive crop without checking acidity and perhaps other matters. He is keen to observe nutritional deficiencies and responses as a guide to supplementary applications and the development of an economical, effective program of fertilization. He is an opportunist in planting soil improving crops at the most advantageous times. He never forgets that a high level of production is a requisite of profits. Fertility problems are the subject of the next chapter. Cropping systems are another fundamental consideration (p. 67).

Management of labor.—Efficiency in use of labor, usually the most costly item of expense, is a factor of major importance. Maintenance of high morale and speedy habits generally is easier where the proprietor has close contacts with his helpers and often works with them. On the large farm it becomes a necessity to keep a suitable number of capable and experienced key-men who can do the more exacting jobs. As foremen or supervisors they must gain the confidence of others.

Proper instruction of workers, so that they may proceed expeditiously with minimum waste of effort, is a factor often overlooked. Continuous study of the ways of doing things, invariable provision of supplies ready at hand for the workers, well-kept tools, and many

other details contribute to lower costs. It is notable that one farm paying a relatively high wage may produce at lower costs to the package than another with lower rates.

Responsibility.—In handling large groups of seasonal laborers it is advisable to find means of establishing definite individual responsibility. When planting, weeding, or hoeing, quite obviously the row becomes the unit by which the foreman may check. In harvesting



22
—Your No.—
LOGAN SPRING FARM
WATTS VEGETABLES
BELLWOOD, PA.
July 8, 1938
The Date
Bruce Enyeart
—Fill in these spaces immediately—Your Name

6 A.M. 7 8 9 10 11 12
12 M. 1 2 3 4 5 6
6 P.M. 7 8 9 10 11 12

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61	62	63	64	65
66	67	68	69	70
71	72	73	74	75
76	77	78	79	80
81	82	83	84	85
86	87	88	89	90
91	92	93	94	95
96	97	98	99	100

(Lost Cards Will Not Be Replaced)

FIG. 30.—Typical time and piece-work card to be checked by proprietor or foreman. A new card is issued daily to each worker who deposits it in lock box at end of day. Regular men are usually employed by the month.

or packing it is the package which becomes the unit of individual responsibility, whether the work is being done by the piece or by the hour.

Identification of packages by markings or by tickets showing the pickers' or packers' pay numbers is neither difficult nor expensive. Every worker then knows that careless, negligent or dishonest work can be traced to the source, whether it is discovered in the field or market. Buyers likewise come to know that there is an element of individual responsibility back of each package. In handling peas and beans, for example, the practice of marking each package with the picker's number has resulted not only in a much higher average grade but in dependable uniformity of pack with consequently better prices.

Obviously the labor problem is simplified by planning crops to provide steady work over as much of the year as possible. The grower who is in position to offer earliest employment in the spring usually secures the best workers. The number of hands should be in conformity with the amount of work; it may be equally costly to have too few or too many.

Timeliness.—By experience and by keeping simple records the grower finds that certain planting times, spraying schedules, and dates for various operations are suited best to his facilities, conditions, and markets. The matured schedule calls for certain activities on certain dates and it is absolutely worthwhile to work by schedule as much as the weather permits. It may not be important whether fall lettuce scheduled for July 20 is sown on that day or a few days earlier or later; but, without a schedule, a week might slip by instead in the press of other tasks. It is the same with successive planting for continuous supplies and with spraying. Because it is unwise to compromise with time and the weather, it is good management to do the job on the exact date, or to anticipate it a day or two.

Precision.—Another fruitful field for management is in the application of methods and devices of precision. Thus, plate-type garden seed drills and testing of seeds enable the grower to sow radishes or spinach, for example, at precise rates. Danger of both thin and crowded stands of plants, with attendant losses, is reduced; seed is conserved. Economies and increased returns follow precise methods at many other points, as in covering seeds, in adjustment of fertilizer machinery, in spacing of plants, in cultivation, in mixing of spray materials, or in uniform but not excessive application of irrigation water.

Bookkeeping and accounting.—Good management includes a certain amount of bookkeeping, at least a record of all receipts and expenses. If a credit business is done, prompt billing and systematic collection are necessary.

Exact cost accounting is difficult where many crops are grown, but it is not impossible and may be worth the effort, with important crops. Costs, however, can be estimated with some exactitude. The grower knows, or can determine and record, the time required to plow, fit, and plant an acre of his principal crops. Costs of fertilizing, spraying, weeding, and harvesting can be computed with fair accuracy. In estimating costs, however, we can be deceived by overlooking indirect costs which must be pro-rated among the several crops. The more important are: depreciation and repairs of buildings, improvements, and equipment; taxes, insurance, interest or rental. Packaging and marketing total more than may be realized. Knowledge of the cost of a package or ton puts spirit into the effort to lower costs of production and to secure top prices.

Simple records of purchases also are invaluable in planning ahead. A summarized guide sheet, showing just what quantities of seeds, fertilizers, spray material, packages, or other supplies have been bought for several years, makes purchasing easier and eliminates a lot of guessing.

Use of capital.—On most vegetable farms profits cannot be realized unless receipts equal capital in at least two or three years. Otherwise overhead costs will consume a disproportionate share of income. It follows that capital must be expended with discretion, skillfully directed into the most productive enterprises. Conversely the operator must endeavor to utilize facilities he owns to assure an output in favorable ratio to the investment. All of this appears rather abstract but is none the less of vital import. Efficient use of capital requires good balancing of the investment to avoid unnecessary limiting factors.

A common error is the failure to make a comparatively small expenditure, perhaps for needed machinery, fertilizers or lime, thereby entailing a considerable reduction in the return from a very much greater investment in labor and land.

Substantial savings usually can be effected by maintaining sufficient working capital, or bank credit, to purchase equipment and supplies at cash discounts.

Care of equipment.—If all tools and implements are completely overhauled during the winter season, worn and defective parts usually may be detected and replaced. Such forehandedness lengthens the life of machinery, reduces depreciation, and practically eliminates costly breaks and delays during the crowded days of the growing season.

Readiness for efficient use and durability depend upon housing when not in frequent use; systematic lubrication, inspection, and tightening of implements; frequent sharpening of hoes and weeders

oiling of unpainted metal parts before storing; and periodical painting.

It is good management to keep on hand a small stock of the machine parts that are most likely to require replacement. A well furnished shop is a great saver of time. Definite places for all tools save annoyance.

Expense for plow shares and various other ground-working parts, especially in highly abrasive soils, sometimes may be reduced by applying a suitable wear-resistant alloy at critical wearing points.

Management of sales is one of the problems that will not remain solved. Market demands, competition, and selling agencies all change rapidly. Individuals and groups, however, that grow, grade, and pack their products in a manner to insure that outstanding quality reaches the consumer's table, and, in addition, trademark their brands, usually find that opportunities exist for getting above the disastrously competitive level on which many perishables often are sold. The principles of good marketing apply equally to wholesale and to retail selling. To emphasize further a point that has been made: how much larger a quantity of green beans and celery would be used, and how much more eagerly buyers would bid, if consumers never found these products over-mature and stringy! Impractical idealism? No! The grower is rewarded, slowly sometimes, but certainly when he consistently manages an exceptionally good job of marketing (pp. 183, 196).

CROPPING SYSTEMS

Cropping systems are arrangements of sequences and of combinations of crops to provide balanced, efficient utilization of soil resources, surface areas, labor supplies, and market possibilities. It is evident that the decisions involved must constitute a major phase of managerial activity.

Crop rotation is the growing of a more or less definite and regularly repeated sequence of crops on the same area. The principal purposes are to utilize most efficiently the resources of the soil and to control insects and diseases.

Crop rotation has long been recognized as a necessity. In vegetable growing, numerous examples of decline in yields and quality, might be cited, which are due primarily to failure to rotate. In some instances entire communities practically have been forced to abandon the culture of a certain crop because of its continuous or too frequent production.

Plants differ greatly in their nutrient requirements. Crops which have about the same requirements should not be planted consecutively, if it can be avoided. Many examples might be given to illus-

trate this point. While this principle should always be considered, certain conditions, such as the use of muck soils or the accessibility of cheap supplies of manure, may justify a system of cropping which would not be permissible under other circumstances.

The importance of rotation to reduce losses from the ravages of insects and diseases deserves emphasis. Many insects and diseases survive the winter in the soil or are harbored in crop refuse on the surface. If the host plants are grown annually these pests are likely to become more and more destructive. Ordinarily, three to five years should elapse between crops of the same species, although less time is sufficient with many crops and more may be required with others.

Unless much manure is to be used, the rotation should include soil improving crops at frequent intervals. It also should alternate crops which furnish considerable quantities of organic matter, such as sweet corn, tomatoes, or beans, with those which leave no substantial residue, such as lettuce and spinach. Crops which require large amounts of organic matter in the soil, such as potatoes and early sweet corn, should be included at the point where their needs will be met most completely. The green manure crops always should be considered as part of the rotation and should be planned accordingly both for their own best development and for the best effect on the crops that follow.

The effect of various vegetable crops on those which follow is not fully understood nor always predictable. Possibly some plants may produce residues that are toxic to themselves or to certain other plants, but this is unlikely to be important in a well-managed soil. Exhaustive utilization of one or more elements by a certain crop, however, may account for unfavorable effects on a succeeding crop with a similiar requirement. Suitable fertilization usually is a practical means of counteracting most of the undesirable effect of a crop upon the succeeding one.

The fundamental principle of rotation is alternation in as many respects as possible. Botanical relationships, nutrient relationships, insect and disease relationships, nature of edible portion, rooting habit, and season of growth all should be considered. In addition, limitations of climate, soil, labor, and market are important factors in planning a rotation. It is not to be expected that a rotation always may be designed in conformity with ideal practice in every respect.

Succession cropping is the growing of two or more crops in sequence on the same land in one year in order to increase the annual production of the area. In truck farming, succession cropping is not general but it is by no means uncommon. For example, early peas may be followed by late cabbage, cauliflower, or tomatoes, or by beans which in turn may be followed by fall lettuce or spinach. Early potatoes may be followed by beans, beets, or spin-

ach in the North, and by sweet corn or many other crops in the South.

In market gardening, intensive succession cropping is the rule—one crop follows another in quick succession. In the North, for example, lettuce plants or onion sets for green bunching may be planted early in April, to be followed by beans late in May, which will be harvested during July in time for fall beets, spinach, radishes, or lettuce. A great variety of early spring crops may be followed by warm-season crops. As many as three, four or five quickly-growing crops sometimes are produced.

The planning of succession cropping requires equal consideration of the probable market, the availability and distribution of labor, and the utilization of the land. Plainly a high state of fertility and liberal fertilization are required for successful, intensive, succession cropping. To gain time the work of fitting the land and of replanting usually is prosecuted most vigorously; sometimes the new planting is completed on the same day that the preceding crop is harvested. An endless variety of sequences may be devised.

Intercropping, also known as companion cropping or double cropping, is the growing of two or more crops on the same land at one time to secure maximum production from a limited area. Thus, two closely-spaced rows of early radishes may be sown between two rows of early cabbage, and lettuce plants may be set in the rows between the cabbage plants. The radishes will be harvested in four or five weeks, the lettuce in five or six weeks, and the cabbage in eight or twelve weeks.

Other typical plans follow. Two rows of beans may be planted between pairs of squash rows, or a single row of beets or small-growing sweet corn between pairs of cucumber rows. Onions to bunch green, spinach, or lettuce may be planted between celery rows, or between the spaces where the celery will be set a little later. A few vines may be pulled at intervals in every second to fourth row of dwarf peas to permit planting tomatoes, cucumbers, melons, or squashes before the peas are ready to harvest. Radishes may be sown in alternate 8-inch rows with lettuce, beets, carrots, or parsnips, leaving 16 inches for the latter crops after the first four weeks. Onion sets are often placed between cabbage or strawberry plants. Early and late varieties of celery sometimes are planted in alternate rows. The early variety is blanched with paper or boards, and, after it is harvested, there is room enough to ridge the late celery with earth for blanching and for protection from early freezes. Many vegetables may be used as intercrops during the first year in perennial vegetables, small fruits or vineyards, and for longer periods in orchards.

Other combinations might be described, but the foregoing will

be suggestive to those whose conditions are favorable for this most intensive type of gardening. It necessarily involves a larger amount of hand work, and, for this reason, is very likely to result in higher cost of production. It is true also that lettuce, onions, or radishes, for example, may be irrigated, specially fertilized, or otherwise nursed along to more advantage when concentrated in solid blocks than when distributed widely as interplants among other crops. Intercropping is less important commercially than it was at a time when labor was cheap, supplies of manure were abundant, and transportation was inefficient.

In making plans for intercropping, the grower should consider carefully the relative times of planting and maturity of the different crops, space requirements at various stages of growth, adequacy of moisture and nutrients, disease relationships, availability of labor, and opportunities for marketing.

It is a common mistake to plant too closely, at distances which do not provide space for proper development. Excessive crowding results in later maturity, many culls, disappointing yields, and disposition to disease. Both succession cropping and intercropping should be managed with consideration for the principles of crop rotation.

Succession planting, as distinguished from succession cropping, is the planting of the same vegetable at suitably frequent intervals to produce a continuous supply. Some growers find it advantageous to specialize in producing a continuous succession of one or more vegetables, try to be "never off the market," and develop a dependable trade with repeating customers as a result. For example, a successful grower on very sandy soil, with irrigation, plants radishes twice each week, regardless of weather, from spring until fall. Others plant radishes, lettuce, spinach, beans, or even sweet corn at weekly intervals over as long periods as the climate permits. Beets, carrots, and onions to bunch should be started at intervals of two to four weeks to provide tender, attractive specimens at all times. It is true that many succession plantings are an annoyance in comparison with single, large-scale plantings, and that costs of production may be higher. The returns, however, often are greater than those secured by risking one or two large plantings with the possibility of the harvests outrunning the labor supply or coinciding with temporarily glutted markets.

MANAGING THE HOME GARDEN

The home vegetable garden is an important feature on practically every farm and its products become a considerable factor in the summer markets of many towns. Thousands of villagers and

suburbanites grow vegetables for their own use and sometimes sell to their neighbors and grocers. Intensive methods are general so that the production is great in proportion to the acreage planted. A diet with an abundance of fresh vegetables counts for health, and work in the garden provides pleasure and relaxation for many business and professional people.

In planning for the home garden, and at every stage of its care, there should be a definite aim to produce a constant supply of high quality vegetables. Good management of the home garden also implies planting a variety of vegetables. The tendency is to restrict the plantings to the most common kinds. Many crops less generally grown could be used to enhance the value of the garden.

Location of the home garden should be convenient to the dwelling, for much of the work will be done at odd times; supplies must be gathered daily or several times a day; the garden, when properly handled, is attractive. For these and other reasons, it is desirable to have the garden near the house. A sandy loam is preferred, but any soil may be improved so that it will produce good results. Thorough drainage is essential. A gentle slope to the south is preferable. There should be protection, natural or artificial, from north and west winds. Close proximity to a supply of water is a great advantage. Water is often needed at seed sowing and transplanting time or for sprinkling. The shade of trees or buildings should be avoided.

In the selection of varieties, quality should have first consideration. Vegetables differ greatly in this respect. Plant the best for the home table, although it may mean a sacrifice in yield. The time required for different varieties to attain maturity also is worth considering to achieve a longer period of continuous supply from a single planting as with sweet corn.

A hotbed or small greenhouse is very useful in starting early plants, but most home gardeners prefer to purchase from local plant growers.

High fertility and frequent tillage are essential. The plot should receive liberal dressings of manure. Rotten manure is most satisfactory, although fresh manure may be used if it is not too strawy or if plowing is done very early. If manure is used freely enough there will be little necessity for the use of commercial fertilizers other than superphosphate, a pound or two to 100 square feet. A complete fertilizer, however, containing about 5 per cent of nitrogen, 10 per cent phosphoric acid, and 5 per cent potash will be beneficial under most conditions. Two to five pounds should be used to each 100 square feet. [See the next chapter for details of the fertility program.]

Special attention is usually given to cultivation, hoeing, and

weeding. A hard surface crust should not be allowed to form, and tillage between the plants should be so frequent that weeds will be unable to start. Fall plowing is an advantage in some heavy soils. When deferred until spring, plowing or spading should be done as soon as the soil is fit so that there will be no delay.

Economy of labor is one of the most important considerations in making plans for the home garden. The old-fashioned garden, where everything is planted in beds between walks, is attractive but requires a maximum amount of labor. It is much better to plant in rows, running lengthwise of the plat. On farms, where there is plenty of available land, the rows should be far enough apart to use a horse cultivator, although some of the smaller vegetables might be planted closer and cultivated with a wheel hoe. Where the area is limited, closer planting is necessary, but the rows should seldom be close enough to prohibit the use of hand-wheel hoes. This type of tool is not as generally used in home gardens as it should be.

Rotation should be practiced as much as possible in home gardening. For example, cabbage and related crops may be at the east side one year, at the west side the next year, and in the center the third year. There must be more or less succession and intercropping. Many crops such as pea, radish, beet, bunch onions, and spinach are planted very early in the spring and are harvested in ample time to plant the same ground in late crops, such as sweet corn, cabbage, cauliflower, beans, turnips, and many other vegetables. Some vegetables, such as parsnip and salsify, require a full season, and this must be taken into account when locating the rows. Small fruits and the perennials, such as rhubarb, horseradish, and asparagus, should be at one side of the garden, so that they will not interfere with plowing and harrowing.

VI

FERTILITY PROGRAM

CONSIDERING the vegetable farm as a factory the soil is the machine most likely to limit or expand the output. The cost of producing a bushel or ton may be doubled or halved with ordinary—not extreme—decreases or increases in yields. Fortunately the soil is exceedingly responsive. The grower who keeps it working at a high level of efficiency is practically assured of larger, more economical yields than the average, often with little or no increase in expenditure of money or labor to the acre. No other factor is so effective as large yields in securing a profit under the competitive market conditions that usually prevail.

The dependence of low unit costs on good crops, the naturally intricate relationships of soil management, and the particular problems involved in the intensive cropping and lavish fertilization common to the vegetable growing business justify rather detailed consideration of the fertility program.

The three main phases of soil management are systematic replenishment of organic matter, suitable liming, and balanced fertilization. Good drainage and proper tillage are assumed.

SOIL ORGANIC MATTER

From ancient times observing farmers have recognized the important benefits of an abundance of organic matter in the soil. Regular and frequent addition of organic matter to the soil is the foundation of the fertility program. This is especially true in vegetable growing because intensive tillage accelerates the decomposition and depletion of organic matter, and most vegetable crops are very sensitive to the unfavorable soil conditions usually associated with its deficiency. Failure to supply adequate amounts of organic matter is certain to result in reduced yields and invites crop failures.

Effects of soil organic matter.—In simple language, soil organic matter may be said to have four general effects: (1) to increase the absorptive capacity; (2) to improve the physical condition; (3) to stimulate biochemical activity; (4) to supply nutrients.

Important increases in the absorptive capacity of mineral soils may be accomplished by incorporating liberal quantities of organic matter. Great reserves of moisture are required for uninterrupted growth and large yields of high quality vegetables. Well decom-

posed organic matter has a very high absorptive capacity, will hold approximately seven or eight times as much water as an equal weight of sand and four times as much as a typical clay. The important benefits of high absorptive capacity include also the ability to retain relatively large quantities of nutrient materials and to decrease thereby the losses that occur by leaching.

The effect of organic matter in improving the physical condition of the soil is particularly notable on heavy loam or clay types. With plenty of organic matter these soils are less plastic; they more readily assume and maintain a granulated structure, tillage operations require less power and labor, the soil remains friable under greater extremes of moisture, and there is less packing, baking, or crusting when dashing or prolonged rains occur or crops must be harvested during wet seasons. Greater permeability of such soils is conducive to rapid absorption of rainfall with consequent reduction in run-off and erosion.

In sandy soils organic matter serves as a binder and supplies more body. Erosion from wind or water is reduced by the presence of fibrous material. Through its combined influences on absorptive capacity and physical condition, organic matter in abundance ameliorates the effects of excessive rainfall as well as drought on all types of soils. Organic matter darkens the color of soil and enables it to warm quickly and absorb more heat.

Readily decomposable organic matter stimulates favorable activities of bacteria, other soil organisms, and chemical processes. Vast amounts of organic matter are required to furnish energy and food for the work of the various soil organisms; it also promotes their activity by improving the aeration of the soil and providing conditions favorable for rapid percolation or distribution of water. In consequence decay rapidly breaks down animal manures or plant residues in the soil and from these releases essential food elements that become available to the growing crops. In addition, the unavailable reserves of minerals in the soil are attacked and progressively converted into available forms, by the action of organic acids that are most abundant in the soil solution when decomposition processes are active. At the same time carbon dioxide escapes to the atmosphere where some of it is used by the new generation of plants. In short, active organic matter in the soil "feeds" the growing crops by decomposing old plant and animal substances and by converting some of the raw materials to available forms.

Certain valuable constituents of fertilizers are converted to unavailable forms less rapidly in soils that are well supplied with organic matter. Such soils are characterized by greater resistance to factors which may increase acidity, and by ability to produce good crops within a wider range of reaction than is possible on

highly mineral soils. There is less tendency toward injury from fertilizers placed very near to roots or seeds.

The effects of active organic matter in supplying nutrients, as indicated in the preceding paragraph, occur directly by decomposition of organic residues and indirectly by reaction of certain by-products upon raw materials. The grower's problem is to supply adequate amounts of suitable organic matter so that decomposition, as the growing season advances, may progressively evolve available nutrients more or less in accordance with needs of the developing crop. Source of the material, provided its amount and character are suitable, is of secondary importance, a matter of convenience and economy. The principal available sources are animal manures, green manures, and crop residues. The effect of any particular application of organic matter, however, is determined mainly by the nitrogen-carbon ratio of the material and also by the fertility level of the soil.

The nitrogen-carbon ratio.—Experienced growers know that good stable manure or a succulent green manure usually produces flourishing, dark-green plants, whereas the same soil with much strawy material plowed under near the time of planting is likely to support only weak, yellow growth for some time, unless fertilizer nitrogen is supplied.

In the first case, the organic material is relatively rich in nitrogen, the ratio being one to about 20 or 30 of carbon. Decomposition proceeds rapidly with comparatively slight demand for additional nitrogen, and nitrogen soon becomes available for the crop.

With the strawy material—mature green manure, dry fodder or straw—the nitrogen-carbon ratio may be as wide as one to 40, one to 80 or more. Carbon, the energy factor, is added to the soil in great excess, creating an enormous microbial demand for nitrogen. With the supply insufficient, decomposition proceeds slowly, excess carbon is gradually converted to carbon dioxide, and the supply of nitrogen available for the crop remains depressed until the ratio has been narrowed. In practice this can be accomplished by allowing considerable time before planting the next crop, or by applying fertilizer nitrogen with the highly carbonaceous materials, or to the crop, or to both as circumstances may indicate.

It may be emphasized that the food requirements of soil micro-organisms and higher plants are similar and sometimes come into direct competition. In such cases microbial demand definitely and successfully asserts priority, occasionally with detriment to the crop. The grower's interest is to arrange for the needs of both, either by avoiding conflict or by providing nutrients.

The nitrogen-carbon relationships of the soil are of practical interest to the vegetable grower in another connection. Inasmuch

posed organic matter has a very high absorptive capacity, will hold approximately seven or eight times as much water as an equal weight of sand and four times as much as a typical clay. The important benefits of high absorptive capacity include also the ability to retain relatively large quantities of nutrient materials and to decrease thereby the losses that occur by leaching.

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The nitrogen-carbon relationships of the soil are of practical interest to the vegetable grower in another connection. Inasmuch

as microbial activity strongly tends to reduce the nitrogen-carbon ratio to the normal status of one to about 10 or 12 it is apparent that the amount of humus finally remaining in the soil must be in rather direct proportion to the supply of nitrogen. Thus inclusion of fertilizer nitrogen with strawy materials which are added to the soil not only overcomes the difficulties of nitrate depression but also secures less wasteful utilization of the carbon, a larger building-up of humus. By such means the grower may overcome some of the objectionable effects of returning resistant material to the soil, whether it is done intentionally to secure greater and more prolonged loosening effect or on account of unavoidable overgrowth of a green manure crop. Rates of application are considered later (p. 89).

It may be added that calcium, lime, is second only to nitrogen in probability of deficiency for the most active decomposition. It should be included with the application of nitrogen unless the supply in the soil is known to be at a good level.

ANIMAL MANURES

Importance of manures.—It is well known that successful vegetable growers in all parts of the world, with all kinds of crops and soils, have in many cases placed their entire dependence upon animal manures. Market gardeners with limited acreage are especially dependent upon animal manure, because intensive planting schedules leave little or no interval between crops for the growing of green manures. Heavy applications of manure assure more rapid improvement of soils and the attainment of a higher level of fertility than may be secured with green manures.

Declining and more expensive supplies of manure, and discovery of the convenience and quick response of growth secured from the use of commercial fertilizers, have led some growers to neglect manuring. But it is now becoming widely understood that the long continued use of commercial fertilizers, without additions of organic matter to the soil, is disastrous. Examples can be cited of gardening operations that have been conducted for many years without manuring, but in all such cases the initial supply of humus has been very large. Eventually difficulties arise. Necessity of replenishing the supply of soil organic matter is the principal reason why vegetable growers buy manure at prevailing prices. As a rule it is cheaper to purchase the needed elements as commercial fertilizer. Manure, however, may be an economical source of the fertilizer elements where it can be secured at very low prices.

An appraisal of the values of animal manure would be incomplete without observing that the effect on production may exceed that to be expected from its nitrogen, phosphorous, and potash, and

the physical improvement of the soil. Its usefulness in supplying the minor elements probably has not been generally appreciated. The organic form of the elements makes the effect longer lasting. Manure is a convenient means of introducing micro-organisms into relatively sterile soil, particularly new muck. It is thought that manure may perform other valuable services, possibly supplying organic plant food or growth-promoting substances similar to vitamins.

Composition of manure.—Ordinary stable manure analyzes approximately 0.5 per cent nitrogen, 0.25 per cent phosphoric acid, and 0.5 per cent potash. About 75 per cent of the weight is water. A ton is equivalent in total nutrients to 100 pounds of 10-5-10 fertilizer (p. 105). The relative deficiency of phosphorus is notable. In terms of common fertilizer materials a 10-ton application of manure supplies the approximate equivalent of 600 pounds of nitrate of soda, 250 pounds of 20 per cent superphosphate, and 200 pounds of muriate of potash, whereas a normal proportioning of the chemical materials would include at least 1000 pounds of superphosphate.

The point is not to depict manure as inferior material, it is exceedingly valuable, but to emphasize the greater efficiency upon reinforcement, or supplemental fertilization, with phosphorus. The three-fold importance of such practice becomes apparent when it is realized that the supply of phosphorus in soils also is low and rather unavailable, and that more or less fertilizer phosphorus always reverts to less available forms.

In ordinary manure about one-half of the nitrogen and potash and one-sixth of the phosphoric acid is readily available, which accounts mainly for the slower-acting but longer-lasting effects of manure in comparison with fertilizer. In considering the composition of manure, credit must be given for the minor elements which are supplied, a factor of importance especially on certain sandy soils and peats of the Atlantic and Southeastern states.

A ton of poultry manure is equivalent to about 200 pounds of 10-8-5, and a ton of unprocessed sheep manure approximates 200 pounds of 10-4-8. In general these manures are about twice as valuable as horse and cow manures.

Reinforcing manure.—The efficiency of manure as a fertilizer is increased notably by scattering superphosphate on the litter in the stable or over the spreader loads at the rate of about 75 pounds of the 20 per cent grade to the ton. The improvement in analysis will make a ton of the reinforced manure approximately equivalent to 200 pounds of 5-10-5 fertilizer, and a 10-ton application would equal a ton of 5-10-5 in nutrient constituents. As previously intimated, it is poor economy to use manure without either reinforcing

it or supplementing it with plenty of phosphorus in the fertilizer used for the crop. Properly handled reinforced manure is a remarkably complete fertilizer.

Characteristics of manures.—Horse manure, particularly that purchased from city stables, is much drier than most other manures and looser in texture, and it acts quickly. It is practically the only kind of manure used in making hotbeds. As its decomposition in piles is very rapid, it must be carefully handled to avoid serious losses of nitrogen. Cow manure is highly valued as a slow-acting manure and may be safely applied nearer to the time of planting. Hog manure is slow in action and generates very little heat in decomposing. Sheep manure is a hot manure and, when sufficiently moist, decomposes very rapidly. It is valued for its fine texture and large percentage of nitrogen, and in usefulness is similar to that of properly handled poultry manure. Sheep manure and poultry manure have long been regarded as excellent fertilizers for onions and for all other garden crops requiring large amounts of nitrogen. Poultry manure is more easily handled when an absorbent such as peat has been used in sufficient quantity to assure fine texture.

Care of manures.—The great value of manure in vegetable gardening indicates the importance of managing the supply with minimum waste and for maximum efficiency. Superphosphate, scattered into the stable litter or troughs at the rate of about 50 or 75 pounds to the ton of manure, will reduce the escape of nitrogen into the atmosphere as ammonia and also will reinforce the supply of phosphorus. In addition, a concrete floor, with depressed center or low walls, will eliminate losses from leaching or runoff wherever manure is stored in the open. Such arrangement is particularly valuable where manure is hauled the year round and can be applied to the land only at favorable intervals in the succession of crops.

Composting manure.—Manure may be piled, or composted, when it cannot be applied at the time, or when it is necessary to condition it for some reason. It may be too fresh and coarse to apply in large amounts immediately before planting. Active fermentation and heating will destroy the weed seeds that invariably are present in fresh manure. If fine texture is desired, the piles are turned from one to three times in a period of several months or more. It is customary to make the piles about four feet deep, with sides that are nearly perpendicular, and then cover as much area as may be necessary. In piles of this form leaching and runoff are minimized, and water may be sprinkled evenly over the entire top as often as necessary to promote decay and to prevent fire-fanging. Composted manure produces a relatively quick and well balanced effect on growth, especially when superphosphate has been included in the pile as suggested.

Time of application.—Generally the best practice is to apply manure to the land as soon as possible after it is produced. In growing truck crops in rotation with general field crops or soil improving crops, the manure may be applied at any convenient time previous to planting, and preferably upon the grass or green manure crops. The probabilities are that yields will be larger than if an attempt is made to store the manure properly and apply it when it is well decomposed.

When very large amounts are applied and planting schedules are close, as in intensive vegetable gardening, rotten or composted manure is almost indispensable. Sometimes a crop may be removed, the manure applied, and the land plowed, harrowed and planted the same day. Under such conditions heavy applications of fresh manure near the time of planting are difficult to incorporate properly in the soil and often produce undesirable effects, perhaps interference with capillarity, temporary depression of nitrates, unbalanced growth, or hairy development of root crops.

If 30 or 40 tons of manure to the acre are available annually, and two or more crops are to be grown during the season, it is often considered preferable to apportion the manure for each crop as may seem desirable instead of using the entire amount at any one time.

Method of application.—As a rule coarse manures and heavy applications should be plowed under. If the manure is fine in texture or limited in supply, the greatest benefit often will be secured by topdressing after plowing, then thoroughly harrowing it into the soil before planting. This is unquestionably the best method for poultry, sheep, and hog manures. On heavy land of moderate fertility, surface applications after plowing are particularly effective in improving physical condition, thus making the soil more friable and less subject to crusting and to washing.

A popular practice in soils of relatively low fertility is to use rotten manure in the hills or rows. This usage is less common among gardeners cultivating soils of high fertility, but it is, without doubt, an advantage in the thinner soils because it secures greater concentration of nutrients in the region of early development of the roots and results in more economical use of the manure applied.

Manure spreaders are in general use because they save labor and secure much more even distribution than is possible by hand spreading. Uniform distribution and fine division of manure usually result in substantial increases in yield over those secured by uneven applications of equal tonnage.

Rate of application.—The rate of application varies with the character and supply of available manure, the condition of the soil, and the kind of crops to be grown. In field trucking, with such crops as sweet corn and cabbage, the applications seldom exceed 10 tons

an acre. An application of 25 tons is heavy today and may be as much as can be used profitably under most conditions. A few growers, however, apply as much as 50 tons an acre where two or three crops are produced in a season. On the other hand, equal or more economical yields have been secured in many cases by reducing these heavy tonnages of manure by one-half and supplementing with commercial fertilizers appropriate to the requirements of the crop, soil, and season of growth.

If manure is scare, and has been applied sparingly, complete fertilizers, such as 4-12-4 or 4-16-4, are likely to prove a more efficient supplement than superphosphate alone. By using green manure crops and commercial fertilizers, with perhaps the additional aid of an irrigation system, the grower unquestionably can economize in the amount of manure. In fact these means of maintaining productivity and yield have enabled many growers to do without animal manures.

GREEN MANURES

Extent and economy.—Through necessity, wherever animal manures cannot be secured, and through choice, on account of lower cost, the growing of green crops for manurial purposes has become general practice. There is no question concerning the effectiveness of a definitely planned and well executed program of green manuring as a basis for maintaining productive soil. This has been demonstrated by skillful growers over a term of years. The problem, however, is more difficult in very light soils, and it may be necessary at relatively frequent intervals to devote a full season to soil improving crops. Vegetable growers, whose activities are not restricted by limited acreage, have come to recognize green manuring as the most effective and economical means of replenishing the supply of organic matter. Another advantage of green manure is lower cost of weed control than with stable manures.

Effects of green manures.—In addition to securing the various important benefits that follow incorporation of organic matter into the soil, the practice of green manuring brings about several other definitely advantageous effects. One of the more important is that the green manure, serving as a cover crop, reduces losses from leaching by utilizing soluble plant food materials that may not have been taken up by the preceding crop or that have developed later. In turn the green manure is plowed under and, by decay of its substance, releases the salvaged nutrients in convenient rates and forms for the use of the cash crop.

The roots of green manurial crops perform valuable service by penetrating into the subsoil and all parts of the topsoil in search of

nutrient substances. These accumulate in the manurial crop and later become easily available for the cash crop that follows. Roots of some green manurial crops, sweet clover for example, are particularly effective in penetrating hard, impervious subsoils. A further advantage accrues when decay of such roots opens countless channels that improve drainage.

Green manures, as cover crops, effectively check erosion. Their presence, in strips or bands across steep slopes and in solid plantings at all possible times, will limit the washing that progressively carries away the best soil. On very light soils in exposed locations, green manures may avert disastrous wind erosion during periods when the land is not occupied by cash crops.

In the case of legumes, green manures are of additional advantage in adding nitrogen to the soil. The quantities of nitrogen which they obtain from the atmosphere under favorable conditions are very substantial—sufficient to warrant reduction and, in some cases, elimination of nitrogen in the fertilizer mixture, which means considerable economy.

When incorporated into the soil in a succulent condition, green manures are remarkably efficient in furnishing a continuous supply of nitrogen for the growth of the crop that follows. This is accomplished from their own decomposition and by activation of the soil nitrogen. They also release directly important supplies of other nutrients and promote availability of the mineral constituents of the soil. Green manures, when plowed under at the succulent stage, may decay more rapidly and support the growing crop more effectively than an equal tonnage of ordinary barnyard manure.

The depression of growth that sometimes occurs when heavy and especially strawy green manures have been plowed under is usually due to a temporary decrease in the supply of available nitrogen (p. 75). It is generally considered that decaying green manures do not cause notable toxicity or acidity, and that such a reaction is very transitory in properly managed soil.

Choice of green manure crops.—In general, legumes are preferable wherever conditions and available time assure satisfactory amount of growth. When conditions are unfavorable for starting a legume, as in October plantings in the North, it is certainly more advantageous to plant a non-legume, such as rye, that is sure to produce a large tonnage of material to plow under. Furthermore, with summer seedings in intensive gardening, the quick, heavy growth made by sudan grass, oats, barley, or rye grass, when planted at proper times and in favorable localities, may be more valuable in conserving the nitrogen remaining from heavy fertilization of a preceding crop than a slower starting, lighter-feeding legume would be in securing atmospheric nitrogen. Indeed the gross feeding and rank

growing non-legumes are most effective in utilizing soil nitrogen tha might be lost and in producing maximum tonnage of organic matte in short periods of time. Although the extensive truck farmer ofte may find greater advantage in the legumes, because they add bot organic matter and nitrogen, the market gardener or intensiv trucker may find it cheaper to buy nitrogen and plant the gree manurial crop that will make the most growth in the least time.

The discussion which follows includes only plants that are mos generally employed for soil improvement on vegetable farms. A order of importance cannot be assigned, as relative usefulness de pends upon circumstances of management and conditions for growtl

Leguminous green manure crops may require inoculatio (p. 89). As a rule legumes do not succeed well on acid soils bu soils which are sufficiently well limed to produce satisfactory veg table crops usually will grow thrifty leguminous green manure crop Heavy, leguminous green manures plowed under in a succulent stat have resulted in just as large yields as were secured with 20 tons c

FIG. 31.—Plowing soybeans, a leguminous green manure. Legumes are preferre where conditions of soil and season are favorable. *Caterpillar Tractor C*

stable manure to the acre. On account of certain disease relationships, some of the legumes may be objectionable in a rotation where many peas or beans are grown.

Red clover is an excellent crop to sow in the North when grain has a place in the rotation. It usually is broadcast in March. Sometimes it is sown just before the last shallow cultivation of crops that mature by midsummer and do not cover the ground too densely. Where it is not likely that moisture in late summer will be too deficient, red clover may be sown in July or early in August on a fine, firm seed bed prepared after harvesting early vegetables. In a few cases it can be sown at the last cultivation of row crops. Seeding rates are 10 to 15 pounds to the acre. Covering for most of the clovers is from one-half inch to one or two inches, depending on soil, moisture, and season.

Alsike clover is more tolerant of acid soil and poor drainage than is red clover and is desirable in mixtures for variable lands. The seeds are very small but germinate well. Six to eight pounds to the acre are seeded alone and proportionate amounts in mixtures.

Crimson clover is adapted best to sandy soils where winters are not severe, particularly along the Atlantic Coast from New Jersey southward. It is commonly sown before the last cultivation of tomatoes, sweet corn, and some other truck crops, or after vegetables that release the land in late July or during August. Seeding rates are about 15 to 20 pounds to the acre.

Sweet clover, either white or yellow, has a wide range of usefulness as a soil improving crop. It succeeds well in hot and in cold climates, and on poor land where the soil is not deficient in lime. It is a sturdy grower and produces large tap roots which effectively penetrate the hardest soils. Sweet clover may be sown alone or in grain in late winter or early spring; sometimes in peas or other early crops. Or it may be sown about midsummer, or slightly later, either at the last cultivation of certain crops or on specially prepared firm seed beds. It is important to note that sweet clover, which is plowed under before the new tops have made a strong start in the spring, is certain to sprout from the tap roots and become a nuisance. It is easily killed, however, by plowing after the new growth is well started and it is especially effective then in supplying nitrogen to the crops that follow. Sweet clover is a biennial plant, which dies naturally after the second summer of growth. Seeding rates range from 15 to 20 pounds to the acre.

Alfalfa is not grown to a great extent for the specific purpose of green manuring vegetable lands but its common culture for forage incidentally serves as an excellent preparation for truck crops. Some growers, however, make very advantageous use of alfalfa solely as a green manure although the seed is usually expensive. Lime require-

ment, seeding rate, and methods of planting are similar to those for sweet clover but somewhat more exacting.

Hairy vetch which is of outstanding value as an over-winter leguminous green manure is used successfully over a wide territory. It is very hardy and an excellent gatherer of nitrogen. When well established in the fall, it is active during mild periods in winter and makes rapid and voluminous growth very early in the spring. The soil under a heavy growth of vetch does not dry out so quickly and cause so much difficulty in plowing as it does under some other crops, such as rye for example. The comparatively large seeds of vetch often germinate and produce good stands under conditions that prove very difficult for the clovers. Hairy vetch often is used in mixtures with rye, timothy, or clover, or with several species together. In seeding alone, rates vary from 20 to 40 pounds to the acre. The chief disadvantage with vetch is the usually high cost of the seed. That, however, is commonly outweighed by its advantages. Seeding time is late summer and fall.

Common vetch is a different species and is adapted only to regions having mild winters. Seeding rates are higher than those for hairy vetch.

Canada field peas, when grown in mixtures of a bushel of peas to two or three bushels of oats to the acre, are desirable as a green manure for starting very early in the spring. Field peas alone are planted at the rate of 3 or 4 bushels to the acre. Cool climatic conditions are required for best results and the crops must be plowed before they become unmanageable. Very few growers, however, find it advantageous to utilize their land or time for planting green manures in early spring.

Cowpeas are a valuable soil improving crop in the South. They require a large amount of heat and no attempt should be made to grow cowpeas in the cooler parts of the North. Under favorable conditions the plants produce a large amount of highly nitrogenous vegetable matter in a short time. The seed should never be sown in the spring until the ground is thoroughly warm. Cowpeas may be planted to good advantage between spring and fall crops; that is, in warm sections spring vegetables may be sold, then cowpeas grown and plowed under before the time for starting fall-planted crops such as spinach. Seeding rates to the acre vary from 60 to 120 pounds.

Soy beans, which tolerate cooler climates and heavier soils than cowpeas, are valued by some northern growers as well as by southern truckers for manurial purposes. Soy beans should not be planted before the local date for planting corn and preferably a little later. They make a desirable summer green manure, but do no

always compete successfully with weeds. Seeding rates are the same as those given for cowpeas.

Non-leguminous green manures.—As previously suggested, this class of green manure crops finds an important place in the soil fertility programs of many vegetable growers. With few exceptions, seed costs are lower, good stands are more certain, and quick yields, or cool season yields, are surer and heavier than with legumes.

American Cyanamid Co.

FIG. 32.—Plowing rye, a non-leguminous green manure. Non-legumes are the most efficient producers of organic matter under many conditions.

Rye is exceedingly valuable as a green manure in the North because it may, with unfailing success, be sown later in the fall than any other crop. It also makes substantial new growth in the spring before time to plant many of the important vegetable crops. In other words, rye is without an equal in producing organic matter on land that can be available for a cover crop only from fall until spring. It is important that growers who use rye extensively for this purpose have not only the necessary equipment but the determination to get the crop plowed under before it becomes too large and strawy or seriously depletes the moisture reserves of the soil. Rates of seeding for heavy growth may range from two or three bushels to the acre in September to three or four bushels by November 1.

Wheat is preferred to rye by some gardeners because it does not attain a large growth so early in the spring; this may be an advan-

tage or a disadvantage according to circumstances. Seeding rates for wheat, as a green manure, are two to four bushels to the acre.

Oats and barley are well suited for sowing in July and early in August, in the cooler sections, as green manure crops to be plowed under in November or later on land intended for extremely early spring planting. When they are not planted too early, in order to avoid the worst heat, and at rates of three or four bushels to the acre, these crops crowd out all weeds and make a great amount of material to work into the soil.

Timothy is most useful as a green manure in cool, moist regions or seasons on loam or heavier soils. In summer or early fall it is sometimes broadcast alone or in mixtures over cucurbits, tomatoes, beans, sweet corn, and other crops which are nearly harvested or soon will be killed by frost. Many of the tiny seeds are covered lightly, by the dashing of rain or by sprinkler irrigation, and germinate well in partial shade. Timothy makes a rapid, dense growth of very fibrous roots and highly nitrogenous tops in the spring. With timely plowing, the effect of a timothy green manure is especially beneficial not only on the structure of the soil but the nutrition of the following crop. Following vegetables that may not serve as nurse crops, timothy can be sown upon specially prepared seed beds. Seeding should be heavier than in general farming—as much as 20 pounds to the acre for maximum production of organic matter at an early date in the spring.

Rye grass is similar in culture to timothy, desirable for midsummer and early fall sowing to make over-winter cover.

Sudan grass is particularly efficient in producing large tonnages of organic matter during the hot, dry weather of July and August. It may be grown successfully only as a warm season crop and is one of the best green manures to use at mid-summer where vegetable crops occupy the land in spring and fall. It is customary to drill or broadcast about 25 or 30 pounds of seed to the acre, with one-half inch to two inches of covering according to conditions.

Field corn is a useful summer green manure when planted with a grain drill.

Buckwheat is valuable as a warm-season green manure for the higher altitudes and for cool regions. It is adaptable to poorer soils, responds readily to fertilizers, makes remarkably heavy growth, and leaves the soil in excellent physical condition. About one bushel of seed is drilled, or 1½ bushels are broadcast and covered by light harrowing.

Millets, sunflowers, and other plants are used locally as green manures. Rape and cowhorn turnips serve as hosts for insects and diseases that attack the cruciferous vegetables and are undesirable on most vegetable farms.

Mixtures as green manures are especially efficient under many conditions. Some of the advantages of both legumes and non-legumes perhaps can be secured in one planting. Two or more plants in mixtures, such as hairy vetch, sweet clover, and timothy, may utilize the resources of soil and light more effectively and assure more complete covering of the land under great variations of soil and season. One plant in the mixture may serve to support another, or to mulch or protect others over winter.

FIG. 33.—Rye and vetch make a valuable over-winter green manure. Even in the North it may grow two feet tall and very dense by May first.

Typical green manure mixtures with quantities of seed commonly used to the acre are: 15 or 20 pounds of hairy vetch with 3 to 6 pecks of rye; 20 pounds of hairy vetch and 10 pounds of timothy; 15 pounds of sweet clover and 10 pounds of timothy; 10 to 15 pounds of hairy vetch, 10 pounds of sweet clover, and 5 to 10 pounds of timothy; 15 pounds of vetch and 10 pounds of red or 5 pounds of alsike clover. Experience and observation will indicate desirable combinations and proportions.

Weeds as green manures are of definite but limited usefulnes They come without expense and may warrant consideration whe they appear luxuriantly following a cash crop. Thus ragweed an foxtail, which thrive in summer and early fall, regularly produc great quantities of organic matter after the very early cabbage an tomatoes have been harvested in some shipping districts. In certai trucking localities, chickweed grows over winter into a mat of grea density but is not very troublesome as a weed in the hot weathe crops that are usually produced. Where the wild plants which ar permitted to grow as green manures are not likely to become seriou weeds, or where unwanted seed formation can be controlled b timely plowing, weeds may become desirable soil improving crops.

Planting green manures.—Seeding rates, time, and, in a fev instances, methods, have been suggested. Additional expense i preparing land and covering seed may be eliminated sometimes b sowing the green manure crop before the last cultivation of suitabl crops, or perhaps immediately behind the cultivator when the seed are tiny. The possibility of earlier planting of some green manure is one important advantage of this method. There is the risk, however, that the green manure crop may start growing with unexpecte rapidity and compete seriously with the cash crop, or that the latte may monopolize light and moisture to the serious detriment or failure of the green manure. Such difficulties seldom occur when opportune seeding times and suitable crops are employed.

Another inexpensive, rapid, and commonly successful method o producing green manures is to broadcast suitable seeds, for exampl rye or vetch, after the last picking of tomatoes or the final cutting o cabbage, and then work down the crop remains and cover the seed by one or more passages of a heavy disc harrow, perhaps with a cultipacker hitched in tandem. By operating the harrow at a rapi speed the refuse usually may be cut and covered sufficiently withou working so deeply that many seeds will fail to push through. Th conservation of moisture and the earlier seeding, by eliminatin plowing and harrowing, may be of greater importance than the saving in expense. Fertilizer residues remain more conveniently available. The green manure often will start more quickly and grow more vigorously than on plowed and conventionally prepared land A modification of this method is to sow small seeds, as clover o timothy, after discing and to cover by cultipacking or rolling.

On the other hand it often is more desirable to plow in preparation for green manures. The ground may be too hard or stony t disc readily, spring plowing may be too difficult after merely discin in fall-planted green manures, or it may be necessary to plow cleanl to combat insects, diseases or weeds. In addition, less seed usuall is required in drilling on well prepared soil than in broadcasting an

harrowing. Cheap and effective seeding of green manures depends upon taking advantage of favorable occasions and circumstances. In dry seasons germination will be aided by rolling or cultipacking after seeding.

Inoculation of leguminous green manure crops is not likely to be required where the particular crop, or one in the same group of relationship to legume bacteria, has been growing within a few years with numerous nodules on the roots. Thus alfalfa and white and yellow sweet clover are inoculated by the same bacteria. Another group includes the vetches, Canada field peas, and garden peas. Red clover, alsike clover, crimson clover, and white clover are benefited by the same bacteria. As garden beans and soybeans are not generically related, they require different bacteria. When in doubt, it is best to introduce the proper bacteria by treating the seed with a good commercial culture, or to spread several hundred pounds to the acre of soil from a field where the legume has been grown successfully.

Fertilizing green manure crops may be necessary to secure substantial growth on poor soils, or on soils that temporarily have been impoverished by a gross-feeding vegetable crop. Additional fertilizer is seldom required after vegetable crops that have been fertilized heavily. If only a moderate amount was used for the vegetable, or if all of it was applied along the rows, the green manure is quite certain to benefit to a profitable degree from an application of 200 to 500 pounds of fertilizer to the acre at the time of seeding. On most soils the formula should be high in phosphorus. Early spring top-dressings with nitrogenous fertilizers hasten development to plowable size and increase both the tonnage and the early nitrogen content of non-leguminous green manures.

In addition to fertilizing green manures to aid their growth it may be profitable, when they become relatively mature and strawy, to fertilize them for quicker decomposition by applying nitrogen before plowing them down. A material that also supplies lime is more effective unless the soil is well supplied with calcium. Nutrients will become more quickly available and most of the nitrogen will be recovered in the next crop. In fact, the yellowing of foliage and the depression of yield which often follows the addition of quantities of strawy material to the soil usually may be prevented by applying about three hundred pounds to the acre of sulphate of ammonia, calcium nitrate, calnitro, or cyanamid, for example, before rather mature green manures are turned under. The general rule is to use about 100 pounds of the common carriers of nitrogen to the ton of dry organic matter (pp. 75, 76).

Fertilizers applied for the growth of green manures or to keep the nitrogen-carbon ratio low are not lost. They are utilized by

the green manure or by the organisms and become available again for the vegetable crop.

Plowing green manures.—In determining the best stage of growth for plowing green manures a number of factors must be weighed. Green manures plowed in succulent condition are relatively rich in nitrogen, decay quickly, and produce the best yields of the crop that follows. Nitrates usually begin to be available for crop use within a few days (p. 96). On the contrary, decomposition of strawy material proceeds slowly and places a demand upon the nitrogen reserves of the soil in direct competition with the needs of growing plants. Nitrogen is seized rather than released by the activities of soil bacteria in such circumstances. When plowing is delayed, either inadvertently or to produce resistant fibrous material that will serve better to loosen the soil, it often becomes desirable to apply nitrogen before plowing, as previously suggested, or to increase the proportion of nitrogen in the fertilizer for the vegetable crop. The ideal stage for plowing a green manure crop is characterized by tender leaves and stems for quick release of nitrates and by more resistant stems and roots for slower decomposition and for improvement of soil structure.

In determining the time to plow green manures it is necessary to consider both the desirability of the stage of growth and the possible difficulties of management. A wet period may produce unmanageably rank and tangled growth. Sudden drought may make certain soils impenetrably hard. When plowing is long delayed the ground may become too dry for germination of seeds or for the successful transplanting of plants. In fact, very late plowing of green manures may permit moisture reserves to drop so low that a satisfactory crop can not be grown if dry weather prevails. It is good management to begin plowing in ample time, even with some sacrifice in tonnage, rather than to gamble too long with the weather. Excellent results are often secured on fertile soils when green manure is plowed, the soil thoroughly compacted, and the new crop seeded within a day, but there is some risk of transplants failing to start well and of poor germination, especially of the oily seeds. It is better to allow a week or two for the first effects of decomposition to pass and for settling of the soil to restore capillary movement of moisture.

The large 16-inch and 18-inch bases are especially efficient in plowing heavy green manures. When the plow is equipped with skilfully adjusted independent jointers and rolling coulters, difficult and varying plowing problems may be met with little annoyance from clogging. A chain or wire, from beam to double-tree, is an effective aid to good covering with the common walking plows. Although plowing is the usual means of incorporating green manures

in the soil, heavy discing may be desirable with some crops on easily worked soils. In some cases it is advantageous to mix the green manure into the soil by discing one or more times before plowing. Otherwise it usually is desirable to place the furrow slice partly on edge, rather than turn it over flat with a resulting mat of material in the bottom of the furrow to break the rise of moisture from the subsoil. Most plows, however, place the material in the form of a loose roll or rope which interferes little with capillarity.

After plowing a green manure the soil, unless wet, should be compacted thoroughly with a cultipacker, heavy disc, drag, or an appropriate combination of these implements. Losses of moisture are reduced, capillarity is restored, and decomposition is accelerated by compacting.

Crop residues are important in maintaining fertility but they seldom are sufficient to assure a satisfactory supply of organic matter. Sweet corn, however, may be characterized as a soil improveing crop when only the ears are harvested and a heavy yield of green fodder is worked into the soil. The residues of other vegetable crops are of value in proportion to the nature and quantity of material returned to the soil. The necessity of burning vegetable crop residues to combat insects or diseases usually may be avoided by plowing them under promptly and cleanly where they grew.

Artificial manure is not generally important. Its production may be practical, however, where waste straw, corn stalks, or similar cellulose materials are available. Even then it may be more economical, except for special purposes, to apply the raw material to the land along with fertilizers to aid decomposition. Various formulae may be used, a typical one being 45 parts of ammonium sulphate, 15 parts of 20 per cent superphosphate, and 40 parts of pulverized limestone. Equivalent amounts of other chemicals may be used. Calcium nitrate or cyanamid, three parts of either, with one part of superphosphate give good results. The straw is placed in successive layers about a foot thick and the fertilizer is applied to each layer at the rate of about 150 pounds to the ton of dry litter. The pile should be straight-sided and concave-topped to absorb rain. Thorough watering at the time of piling and at appropriate intervals thereafter will hasten decomposition. The time required for decomposition is four to eight months. The yield is about two and a half tons of wet manure from a ton of dry straw and the quality may be equal to that of ordinary barnyard manure.

Concluding the discussions of organic matter in relation to the fertility program it is emphasized that frequent additions of readily decomposable organic matter to the soil, and its consequent presence there in various stages of decomposition, are essential to the production of high yields of vegetable crops. Furthermore, or-

ganic matter in abundance not only promotes soil fertility but with lime it provides conditions for the fully effective and profitable use of commercial fertilizers.

USE OF LIME

The term lime, as it is used agriculturally, includes the various calcium and magnesium bearing materials commonly applied to improve the conditions of acid soils.

Importance of lime.—Careful attention to the lime requirement is essential to the maintenance of high fertility and the economical, effective use of fertilizers. Calcium is conspicuously important in the involved chemical activities of the soil and in the nutrition of both soil organisms and crop plants. When it is deficient, satisfactory responses from fertilizers are impossible because of the interdependence of growth processes on a balanced supply of plant food elements.

Soil reaction.—The degree of acidity is a convenient and fairly reliable indicator of the physiological condition of the soil. A number of factors persistently tend to increase soil acidity in humid regions. Losses of calcium by percolation into the drainage water are enormous—much greater than losses of other important elements. Quantities of carbonic acid—useful however in improving the solubility of phosphates and potassium—are developed from carbon dioxide generated by decomposition of organic matter. Considerable amounts of lime are removed by crops, and acid-forming fertilizers or sulphur-bearing insecticides often are used.

Some of the unfavorable soil conditions generally associated with too high acidity are deficiency of calcium and magnesium, decreased bacterial activity with low availability of nitrogen, low availability of native phosphorus and reversion of phosphoric acid from fertilizers, development of soluble toxic aluminum, and excessive solubility of manganese and iron.

At the other extreme, various detrimental conditions may develop in neutral or slightly alkaline soils, deficiency of available manganese and possibly of iron usually being the first to concern the vegetable grower. In arid lands the problems associated with alkalinity often are serious. The intermediate situation, slight to moderate acidity, undoubtedly is most favorable for beneficial activities of the soil and for growth of most crop plants.

The degree of soil acidity is ordinarily stated in terms of pH, an expression which is used as a measure of the hydrogen-ion concentration. The pH is the Briggs logarithm of the reciprocal of the hydrogen-ion concentration. A pH of 6.5 designates a hydrogen-ion concentration of $10^{-6.5}$ gram-equivalents of H^+ per liter. This

designation accounts for the fact that a low pH indicates a high concentration of hydrogen-ions, or a high degree of acidity. Thus, pH 7 is neutral, pH 8 is the first unit in the alkaline range, and pH 6 is the first unit in the acid range. Increases up and down the scale are tenfold with each unit, thus intensity of acidity at pH 5 is 10 times greater than at pH 6, and 10x10 or 100 times greater than at pH 7. The usual range of humid region mineral soils is pH 5 to pH 7 and most crops thrive when the reaction is between pH 5.5 and pH 6.5. In common usage the expression *slightly acid* is applied to soils in the range pH 6 to pH 7, *moderately acid* to the range pH 5.5 to pH 6, and *highly to moderately acid* to the range pH 5 to pH 5.5. When the intensity is greater than pH 5 the soil is said to be *strongly acid* or *highly acid*.

Concerning the need for lime, as apparently revealed by tests for acidity, the results should always be considered indicative rather than absolute. They must be interpreted with due consideration of such other factors as soil type, amount of organic matter, tolerance of the crops, and the species of plants found thriving well upon the land. On the vegetable farm vigorous growth of lambs-quarter, purslane, and chickweed is usually indicative of a satisfactory reaction for acid sensitive crops.

Typical symptoms of excessive acidity are prevalence of acid-tolerant weeds such as sorrel, stunting of spinach, extremely red foliage and stunting of young beet plants, browning of roots and the growing hearts or tips of sensitive plants such as celery, marked yellowing of foliage as sometimes observed in celery, and failure of fertilizers to produce satisfactory responses.

In interpreting ordinary acidity tests it has occurred that alkaline residues from very heavy, long-continued applications of nitrate of soda have masked a deficiency of calcium and magnesium on intensively cropped lands. In cases of doubt a test for calcium will reveal the true situation.

Acidity tolerance of vegetable crops.—Exact ranges can not be specified because a sensitive crop may succeed on one soil and fail on another that is alike in reaction but different in other characteristics. It is essential to good soil management, however, to know the usually suitable pH range and relative tolerances of the important crops. On account of the many variables involved it is natural for slight variations to exist in the recommendations of authorities. The table on page 94 is from Cornell Extension Bulletin 281.

On some soils the lowest pH for best growth may be about 0.5 higher than the minimums given. By making numerous tests among the growing crops the shrewd grower learns the limits on his own land.

APPROXIMATE RANGE IN SOIL ACIDITY FOR VEGETABLES ON UPLAND SOILS, AND SUGGESTED QUANTITY OF LIMESTONE* NECESSARY TO BRING SOIL REACTION TO DESIRED RANGE

Crops	*Desired range*	*Quantity of limestone to apply to a soil*		
		Moderately acid, pH 5.9 to 5.5	*Medium strongly acid, pH 5.4 to 5.0*	*Strongly acid, pH 4.9 to 4.5*
Sensitive crops † Asparagus, beet, celery, leek, lettuce, onion, parsnip, salsify, spinach	*pH*, 6.8 to 6.0	*Tons* Light soil, ½ Heavy soil, ½ to ¾	*Tons* Light soil, ½ to 1 Heavy soil, ¾ to 1¼	*Tons* Light soil, 1¼ to 2 Heavy soil, 1½ to 2½
Moderately sensitive crops Broccoli ‡, cabbage ‡, carrot, cauliflower ‡, muskmelon, pepper	6.8 to 5.5	No limestone needed	Light soil, ½ to ¾ Heavy soil, ¾ to 1	Light soil, 1 to 1¼ Heavy soil, 1¼ to 2
Broadly tolerant crops Beans (field, snap, and lima), Brussels sprouts ‡, chard, cucumber, dandelion, eggplant,[11] endive, kale ‡, kohlrabi, parsley, pea, potato §, pumpkin, radish ‡, rhubarb, squash, sweet corn, tomato, turnip ‡, and watermelon.	6.8 to 5.0	No limestone needed	No limestone needed	Light soil, ½ to 1 Heavy soil, ¾ to 1½

* Three-fourths as much hydrated lime as of limestone may be used in these recommendations.

† Liming soil for beets may increase scab if the scab organism is present.

‡ Crops in the mustard family are susceptible to injury from club root. Where this organism is present, special treatments are recommended.

§ While potatoes respond somewhat to lime, the soil should be kept at pH 5.0 to 5.5, to reduce scab.

[11] Where eggplant wilt is prevalent, the reaction should be at pH. 5.0 to 5.5.

Forms of lime.—In general it pays best to use whatever form of lime costs least in terms of either total oxides or neutralizing power, after including the expense of transportation and distribution. The caustic forms, burned and hydrated limes, may be slightly quicker acting and are more effective in combating club root of crucifers. But pulverized limestone is used most widely among vegetable growers because it is relatively inexpensive in many places, is not caustic to handle, and can be applied evenly through fertilizer distributors. There is no question concerning its effectiveness provided half or more of the material will pass a 100-mesh sieve, and all will pass a 10-mesh screen. Many brands are much finer. Even coarser grades can be used advantageously when they are so cheap that the quantity per acre can be increased to supply the required amount of finely pulverized material. As they are ordinarily available, two tons of ground limestone, about a ton and half of hydrated lime,

and one ton of burned lime are approximately equivalent in neutralizing power. Ground oyster shells and marl are used extensively where locally available. Their composition approximates that of pulverized limestone.

Ordinary limes usually supply sufficient magnesium. High magnesium or dolomitic limes, however, may be more effective under some conditions, particularly on certain sandy soils disposed to magnesium deficiency.

In a few circumstances it may be desirable to supply calcium without decreasing acidity. Superphosphate is practically neutral in its effect on the soil. It may serve as a source of calcium for such crops as potatoes and sweet potatoes when the soil reaction is near the permissible maximum, and under these highly acid conditions its phosphorus may counteract toxic compounds.

Applying lime.—Careful growers never plant a crop that is sensitive to acidity without determining the soil reaction, and applying lime if it is needed. Conversely it is unbusinesslike to use lime merely on the assumption that it is needed. Unnecessary liming wastes money, and in highly excessive amounts it may make certain minerals unavailable, especially manganese and iron. In addition, it often is desirable to include crops of such dissimilar tolerances as cabbage and potatoes in a single rotation. Because the minimum pH of one is practically identical with the maximum pH of the other, unnecessarily heavy liming may incur needless risks.

It follows that the best point in rotation for applying lime is in preparing the soil for the most acid-sensitive or lime-responsive crops. Lime is usually applied on plowed and roughly leveled land. Very even distribution, which can be secured only by mechanical spreaders, and thorough, prompt working into the soil are required for maximum early benefit. To avoid caking or balling the caustic forms especially should be spread at times when the soil is not very wet, and should be harrowed into it promptly.

Rates of liming.—On lands that have not been limed for many years as much as two tons or more of pulverized limestone to the acre, or the equivalent in other limes, may be required. Apart from such heavy initial applications it is considered better practice to make lighter applications, 1000 to 2000 pounds to the acre, as frequently as regular testing and the tolerance of the crops grown may indicate. The table (p. 94) shows applications for various conditions.

FUNCTIONS OF FERTILIZERS

The expression *commercial fertilizers* includes the various materials, other than manures, that are applied to the soil to furnish essential plant food elements. Nitrogen, phosphorus, and potas-

sium, the elements most often found deficient for well-balanced growth, are ordinarily provided in fertilizers. Calcium or magnesium may be inadequate in neglected soils but they are supplied by liming to regulate the soil reaction. Sulphur is of major importance however; it is added to the soil incidentally by the extensive use of superphosphate and sulphate of ammonia. Occasionally manganese copper, boron, or some other element may be needed.

Importance of fertilizers.—Although fertility can be maintained with liberal applications of animal manures and without fertilizers, manure alone is an unbalanced and wasteful ration. It must be supplemented with fertilizer phosphorus for completely effective and economical use. Supplies of manure, however, have declined and become costly in terms of fertilizing elements. At the same time improvements in analysis, condition, relative price, and methods of using fertilizers have made them more profitable. Finally increasing dependence upon green manures for organic matter and the complete lack of animal manures on many farms have made the use of commercial fertilizers a matter of universal necessity.

Advantages of fertilizers.—An especially important advantage is the very quick effect that may be secured from readily available forms in early spring plantings and the quick, controllable effects in later side-dressing of growing crops. In comparison animal manures are slow in effect; the fertilizing values become available only as decomposition proceeds, which is a very slow process in cold or wet soils. In this connection it may be noted that nitrification is most rapid at 80° F. to 90° F., slower at low temperatures, and practically stops below 40° F.

Other important advantages of fertilizers are: relatively low cost of nutrient elements; small labor requirement in hauling and applying; uniform and known composition; choice of availability of nitrogen, and modification of analysis to conform with different requirements. Surprisingly large crops often may be secured with skilful use of fertilizers and lime on poor soils having good physical condition.

Fertilizers are indispensable in securing a quick start, uninterrupted development, and earlier maturity. Often time will be gained for another cash crop, or earlier planting of a green manure. Large, certain yields and high quality are closely associated with rapid growth of vegetables. Slow growth is likely to cause bitter or pungent flavors and tough or stringy structure. Adequately fertilized vegetables usually are superior in attractiveness, palatability, and nutritional value.

Balanced fertilization.—Interdependence of fertilizer effects is a matter of utmost importance. For example, it may be thought there is too much nitrogen when cabbage forms puffy, loose heads.

s possible, however, that there may be only relative excess of ogen with actual deficiency of phosphorus and potassium. Maxm benefit cannot be secured from the application of one or two ilizer elements under conditions of deficiency of another. Opum functioning of both micro-organisms and crop plants occurs with the balanced and interlocking effects of an adequate sup- of all essential elements, and is impossible otherwise. Although ct nutrient balance may be unattainable, on account of unknown variable factors of soil, weather and crop, it will be approached e nearly when the fertility program includes suitable addition of anic matter and lime as well as specific fertilization of the crop. is the plants will be more broadly supported by development and ization of the native resources of the soil along with the applica- of commercial fertilizers.

The use of nitrogen.—Of the three elements commonly sup- d to vegetable crops by fertilizers, nitrogen is more frequently limiting factor than either phosphorus or potassium because, in ivated soils, it is lost more quickly and, also, because it is more ensive, and, therefore, less likely to be applied in adequate ounts. Nevertheless, vegetable growers sometimes use too much ogen without sufficient phosphorus and potassium. Of the three the one most likely to be detrimental when supplied in excess.

Nitrogen plays the most important part in encouraging above- und vegetative growth, and, therefore, is particularly valuable ecuring large yields of succulent quality of the leafy crops such as bage, cauliflower, celery, lettuce, and spinach. Even the seed- and t-producing vegetables usually are benefited by liberal and well- d use of nitrogen, provided the mineral elements are in good oly. For example, application of nitrogen to tomatoes, egg- ts, or peppers after the fruitful period has begun often will re- e vigor, make plumper fruits, and lengthen the productive od. An abundance of nitrogen is very necessary in growing a early crops of lettuce, beets, onions, or other vegetables. The e common effects of too much nitrogen are delayed maturity, eased resistance to disease, and impairment of shipping quality xtreme succulence.

Nitrogen deficiency is marked by slow growth, or checked vth where the supply has been adequate for a time, and by very acteristic yellowish-green color. Normally green, thrifty foli- is associated with satisfactory supplies of nitrogen. Nitrogen iency may become acute, perhaps suddenly and unexpectedly, ny stage of growth—for example, after long rainy periods have ed excessive nitrogen usage in rank development of foliage, unusually heavy losses from leaching. Nitrogen deficiencies not always readily foreseen or understood. Fortunately, they

may be corrected easily and conveniently because nitrogen in solu forms moves freely with the soil solutions and may be applied the surface when there is moisture to carry it down. The use fertilizer nitrogen in overcoming the temporarily detrimental effe of large applications of strawy materials has been discussed (p. 7

The initial fertilizer application usually should supply part its nitrogen in the nitrate form and the remainder in one or m less soluble forms to become available more slowly. Additio nitrogen may or may not be required later. Nature of the ini fertilizer, soil type, amount and character of organic matter, quirements of the crop, and weather will determine the necess number, and frequency of later applications.

On heavy soils it often pays to apply all or nearly all the nitro at the time of planting. Losses from leaching on such soils are than may be supposed. Even on fertile loams, if they are well s plied with organic matter, it may be best for some crops to use the nitrogen to get a vigorous start, with later dependence u nitrification. On sandy and porous soils, however, division of fertilizer into two or more applications, at intervals of ten days several weeks, is generally more economical and effective. Cert crops respond especially to applications of nitrogen at critical stag such as celery when blanching is undertaken, cauliflower when th is danger of growth being checked, and staked, pruned tomat after production begins. Very early plantings may require seve applications of quickly-acting nitrate of soda or calcium nitrate, example. Thus a rapid rate of early growth can be supported t would be impossible with manure or organic fertilizers. The effe of excessive rainfall on nitrogen requirement have been mention Skilfully timed applications of nitrogen often secure prompt p nounced effects that return large profits from a small investment fertilizer.

Methods of applying fertilizers are discussed later. Howev quickly-acting forms of nitrogen often may be applied to advant by special methods. Nitrate of soda, calnitro, and calcium nitr preferably in pelleted form, are commonly used for broadcast over the growing crops with a full swing of the arm, or with a clone seeder, as when sowing clover seeds. Amounts commonly u range from 100 to 300 pounds to the acre. The broadcasting m be done when the foliage is dry. Then nearly every particle rebound or glance to the ground, particularly when the pelleted terials are used, and only a negligible amount usually adheres to leaves. Many gardeners have found this labor-saving method s even with plants which have tender leaves. With widely-spa plants the material may be broadcast only over the rows or at sides. Sulphate of ammonia adheres to foliage more than nitr

of soda and is likely to cause burning unless deposited between the rows.

To avoid all danger of injury to foliage, and to secure even distribution, some growers use distributors mounted on cultivators or operated independently, which apply the fertilizer at the sides of the rows, in the soil, or over the entire space between the rows as desired. In dry weather it is an advantage to place the fertilizer down in the soil, if the roots and foliage are not too far advanced for safe cultivation.

FIG. 34.—Broadcasting pelleted nitrate of soda in topdressing early onions.

Sometimes nitrogen fertilizers are dissolved at the rate of about one ounce or less to a gallon of water and applied through the sprinkler irrigation system or with the garden hose or sprinkling can. Some growers add nutrients to the water applied through the transplanting machine, usually about one ounce to the gallon of water (p. 132).

Discussions and analyses of nitrogen fertilizers, as well as of carriers of phosphorus and potassium, will be found later in the chapter.

The use of phosphorus.—The balancing influences of fertilizer phosphorus are notable. It counteracts the effects of too much nitrogen, excessive liming, and high acidity. It builds up the essential element usually most deficient in the soil. In fact nearly all

soils are lacking in phosphorus and its liberal addition almost invariably produces profitable responses.

Its most conspicuous effects in the plant are to hasten maturity to stimulate flowering, fruiting, and the development of seeds. Phosphorus is important in securing early maturity, not only of peas, beans, sweet corn, tomato and other seed or fruit forms of vegetables, but it also hastens the development to marketable stage of foliage vegetables, such as cabbage or lettuce. Liberal use of phosphorus to promote maturity is especially valuable in short, cold, or wet seasons. Ample phosphorus is conducive to extensive and vigorous root development with better drought resistance, greater resistance to disease, and higher food value.

Phosphorus deficiency, which is not easily recognized in mild degree, definitely limits growth, retards maturity, and reduces yields, causing a situation of which the grower often is not aware. In extreme cases the foliage becomes very dull green, bronzed or purplish, the root system is restricted, and the flowers tend to drop.

With a few exceptions, most often found on extremely porous soils, it is customary to include all the phosphorus in the fertilizer used at the time of planting. Losses of phosphorus by leaching are negligible. On account of the relative immobility of this element in the soil, full effectiveness of phosphatic fertilizers can be secured only with placement below the surface within the zone of greatest root activity.

An important consideration in the use of phosphorus is the tendency of most soils to convert the phosphoric acid of fertilizers to relatively unavailable forms. Soils exhibit marked variations in this respect and the loss of fertilizer efficiency may be very great with especially unfavorable circumstances. Band placement (p. 111) may be helpful in reducing losses from fixation. Proper liming, neither scanty nor excessive, however, is the most important single factor in securing maximum effectiveness of phosphatic fertilizers.

The use of potassium.—The influences of potassium are essential in many plant processes, especially carbohydrate manufacture and translocation, protein formation, and cell division. Potash increases resistance to disease, encourages root development, and balances the effects of nitrogen and phosphorus. An abundance of available potash is absolutely necessary for the production of large yields of plump, well-formed root crops and potatoes, on account of its stimulating effects on starch formation and cambium activity, the latter being directly related to diameter increases. Potash is important in securing shapely, solid solanaceous fruits and cucurbits. Yields of all crops are reduced when it is insufficiently available.

Lack of available potassium results in slender development of roots and tubers, as "stringy" sweet potatoes. Tomatoes become

flat-sided and thin-walled; cucumbers and muskmelons grow necklike or pointed at the stem ends. In the foliage, potash deficiency may appear as "leaf scorch," mottled or blotchy coloration between the veins, and progressive browning or dying at the edges. In severe cases lower leaves may die and remain attached to the plant.

The supply of potassium in the soil is generally rather abundant, with the exception of sands and mucks, but readily available forms are often inadequate. Good tillage, however, with careful attention to organic matter and lime, usually accomplishes substantial improvement in the capacity of native soil potash to support crops.

With a few exceptions, more or less fertilizer potash can be used to advantage in growing nearly all kinds of vegetables under nearly all conditions, and liberal amounts generally must be provided for root and tuber crops, sandy soils, and muck lands. The usual custom is to include all the potash, as well as the phosphorus, in the initial application and to have these elements in sufficient amount to provide a background for maximum effective use of nitrogen, perhaps in part as later top-dressing. Better results will be secured by placing potash fertilizers within convenient reach of the roots, rather than by depending too much upon processes of solution to carry the nutrient constituents down from the surface. Although all the potassium usually is included in the initial fertilization, it is not uncommon that a side-dressing will increase the crop, especially when potash-loving crops are grown on naturally deficient soils.

Other elements as fertilizers.—Calcium, magnesium, and sulphur are usually supplied in sufficient incidental amounts by ordinary liming and fertilizing. Any doubt concerning the adequacy of magnesium may be inexpensively settled by using dolomitic liming materials. Deficiency of magnesium appears as yellowish mottling or chlorosis of the older leaves in which the coloring breaks down in patches, forming brown spots between the main veins. The affected leaves usually die prematurely and fall, whereas the younger leaves may continue to appear normal.

Manganese deficiency is most common on certain sandy, marl, and peat soils, or those which have been limed excessively, and becomes apparent in yellowing between the veins of the younger leaves. Manganese sulphate can be applied to the soil at rates of 25 to 50 pounds to the acre. Manganese chlorosis of beans is fairly common but can be overcome by about two sprayings with a solution of 4 pounds of manganese sulphate in 50 gallons of water.

Copper deficiency is most familiarly shown in thin skins, unsatisfactory coloring and poor keeping quality of onions and rabbit's ear of lettuce in the production of these crops on some peats and mucks. Applications of as little as 25 pounds and as much as 300 pounds of finely ground copper sulphate to the acre have been used.

Boron deficiency has been associated with cracking of celery, dark center of root vegetables, browning of cauliflower curd, and other troubles. Ten pounds of borax to the acre in broadcast fertilization or 5 pounds in bands has been considered sufficient. Heavy applications may be detrimental.

For some crops on certain sandy soils zinc in the form of zinc sulphate has been found beneficial.

Deficiency of the minor elements is comparatively uncommon except on certain soil types, and the grower should not hasten to include them in his program. As stated elsewhere, stable manure, and also certain natural fertilizers, are usually effective sources of the minor elements. However, in localities known to be subject to deficiencies it may be convenient to use the ready-mixed fertilizers in which the manufacturers have included often lacking elements. If nutritional difficulties persist, in spite of good general management of the soil, expert counsel should be sought.

FERTILIZER MATERIALS

A brief discussion of the more typical and commonly available fertilizers will suffice. They are grouped for convenience according to the three principal elements; however, some of the materials supply more than one nutrient.

Nitrogen fertilizers.—Nitrate of soda (15.5-16 per cent nitrogen) is probably the most generally useful nitrogen fertilizer for the vegetable gardener. Its complete solubility, quick effect, and slight disposition to cause injury to roots or tops, when properly applied, have made nitrate of soda universally popular. It leaves an alkaline residue of unimportant consequence under average conditions. In a few instances detrimentally large accumulations of sodium have occurred from long continued very heavy applications of nitrate of soda. Under such conditions the soil tends to become puddled and root development is impeded. Natural nitrate of soda, distinct from the synthetic material, generally supplies sufficient manganese and boron for balanced nutrition. The percentage of nitrogen may be slightly higher in the synthetic kind.

Calcium nitrate (15 per cent nitrogen) is nearly ideal, supplying nitrate nitrogen with a calcium residue. Excessive deliquescence—absorption of moisture from the air—however, renders the material difficult to store and handle.

Calnitro (16-20.5 nitrogen) and Calurea (34 per cent nitrogen) are among the newer materials that compete as nitrate carriers. The second supplies ammonium nitrogen as well and both leave calcium residues in the soil.

Sulphate of ammonia (20.5 per cent nitrogen) is considered al-

most as quick in effect as nitrate of soda and may be used in much the same way. It usually costs less per unit of nitrogen and is used extensively. The pronounced acid effect on the soil—nearly 1½ tons of ordinary agricultural limestone are required to neutralize the effect of a ton of sulphate of ammonia—may not be objectionable where lime is cheap, and is useful in lowering pH for acid-loving crops. When lime is supplied in adequate amounts, sulphate of ammonia compares favorably in results with equivalent amounts of nitrate of soda.

Cyanamid (22 per cent nitrogen) changes in moist soil to lime and urea, the urea in turn changes to ammonia and at length to nitrate of calcium. Losses from leaching are likely to be less and the effect somewhat slower than with the forms of nitrogen previously described, but sufficiently rapid to secure effective response from preplanting applications. As cyanamid exerts a temporary sterilizing effect, planting should be delayed until the material has been in contact with moist soil for at least three days for each 100 pounds of application to the acre. With applications of 1000 pounds, or more, to the acre the toxic effect may be used under circumstances to combat weeds, club root, or nematodes. Cyanamid is equivalent in liming effect to about an equal weight of pulverized limestone.

Ammophos (16 per cent nitrogen and 20 per cent phosphoric acid, also 11 per cent nitrogen and 48 per cent phosphoric acid) is a valuable concentrated material that is available in two grades, carrying both nitrogen and phosphorus. The nitrogen is similar in availability to that from sulphate of ammonia. Ammophos lends itself well to home mixing.

Nitrate of potash (usually 13 per cent nitrogen and 44 per cent potash) is a quickly soluble, very concentrated material similar in effect to nitrate of soda but with the addition of potassium. The vegetable grower finds this material especially useful for top-dressing where there is need for potassium as well as nitrogen, for example on outdoor trellised tomatoes or on greenhouse tomatoes or cucumbers, and in the preparation of nutrient solutions.

Urea (46 per cent nitrogen) is a manufactured form of organic nitrogen that is readily converted in warm soils to ammonia and nitrates. It is a desirable form of nitrogen and is without important residual effect.

Animal tankage, dried fish scrap, cottonseed meal, and other carriers of organic nitrogen in the form of animal or vegetable matter are valued especially in mixtures for sandy soils, where their slower effect serves the later nutrition of the crop with minimum loss from leaching. Most of them contain 5 to 10 per cent of nitrogen. These materials are often included in mixtures, ordinarily about 300 pounds to the ton, for their effect in preserving good physical con-

dition. They are used to a lesser extent than formerly on accoun of the higher unit cost of the nitrogen they contain. There is nc evidence to indicate that organic nitrogen, in general, is superio to inorganic nitrogen, or the opposite. Either may be superior fo certain purposes, but it makes little or no difference provided the application of nitrogen is managed so that it will supply the plan properly at all stages of growth.

Phosphatic fertilizers.—Superphosphate (16 to 20 per cen available phosphoric acid, and up to 45 per cent in concentratec forms) has been for a long time the most widely used of phosphatic fertilizers and continues to be an economical and desirable source Superphosphate is generally used in making complete fertilizers The double and treble superphosphates are desirable for mixing fertilizers of high concentration and where transportation and handling costs are large. Gypsum, calcium sulphate, is the principa residue of superphosphate. Its effect on the pH of the soil is negligible.

Raw rock phosphate (25-30 per cent *total* phosphoric acid) is rarely used in vegetable gardening on account of very slow availability. It is useful as a reinforcement for stable manure.

Ammophos, as indicated under nitrogen fertilizers, is a concentrated fertilizer of desirable characteristics.

Ammoniated superphosphate (2-3 per cent nitrogen, 16 per cent superphosphate) is useful when a little nitrogen is wanted with phosphorus.

Bone meal, particularly in the steamed form, is fairly quickly available and contains about 23 per cent of total phosphoric acid It is especially effective when distributed in the furrow, perhaps stirred into the soil beneath the plants in small handfuls before transplanting. Bone meal also contains a small percentage of nitrogen and is an excellent conditioner for mixing fertilizers. The cost of phosphorus on a unit basis is approximately twice as much in bone meal as in superphosphate.

Basic slag contains lime and iron in addition to about 16 per cent phosphoric acid. As a rule it is not so economical or effective as superphosphate.

Potassium carriers.—Muriate of potash (48-60 per cent potash) is used largely by vegetable growers. It usually costs less per unit of potash than other carriers and is very satisfactory in mixtures.

Nitrate of potash was mentioned under nitrogen fertilizers and is a very useful material when it can be purchased at favorable prices.

Sulphate of potash (48 per cent potash) is a satisfactory material but it is seldom economical for ordinary purposes. It is sometimes preferred to muriate, the chloride, for potatoes.

Kainit (12-16 per cent potash) is the crude potash as mined and probably not so cheap as the more concentrated forms.

Wood ashes (3-7 per cent potash and 1-2 per cent phosphoric acid when unleached) may be used where they can be obtained cheaply. They also supply considerable lime.

Tobacco stems (4-9 per cent potash, 2-4 per cent nitrogen) are especially useful as a conditioner in mixtures.

COMPLETE FERTILIZERS

Complete fertilizers and concentrations.—The term "complete fertilizer" is ordinarily applied to mixtures containing nitrogen, phosphorus, and potassium. The analysis "5-10-5," for example, is expressed as percentages of nitrogen, phosphoric acid, and potash in the order named. Different degrees of concentration may be illustrated by showing that 1200 pounds of 5-10-5 fertilizer, 600 pounds of 10-20-10 fertilizer, and 400 pounds of 15-30-15 fertilizer would contain exactly the same amounts of the nutrients named in the several analyses. If equally acceptable materials were used in their manufacture, little if any difference would be expected in yields produced by equivalent amounts of fertilizers of the various concentrations. The cost per unit of nutrients, including cost of transportation and application, is usually of more importance.

Fertilizer ratios.—The several analyses mentioned in the preceding paragraph were all in the ratio 1-2-1, and all would contain exactly the same proportions of nitrogen, phosphorus, and potassium —a ratio that is successfully applied to the production of a great variety of vegetable crops over a wide range of conditions. A fertilizer with a 1-2-1 ratio is probably more generally useful than any other in vegetable gardening. However, on fertile soils, or where legumes or manures have been used freely, and particularly for the fruit or seed-bearing vegetables, a ratio of 1-3-1, or even 1-4-1, is likely to produce earlier and larger yields. For the root crops, potatoes, and perennial crops a ratio of 1-2-2 is used most frequently and is advisable for many other vegetables on very sandy soils. Ratios of 1-1-1 are occasionally used for rapidly growing leafy vegetables. As a rule, where a ratio of 1-2-1 or 1-3-1 would be right for very early planting of a crop on a certain soil, a ratio one point higher in phosphorus, as 1-3-1 or 1-4-1, would be more effective for later planting of the same crop on the same soil. Furthermore, the figure for phosphorus generally should be one or two higher when much readily decomposable manure or green manure has been turned into the soil than it would be for the same crop and soil without the benefit of high grade organic material.

Fertilizer formulae.—In the language of the fertilizer trade.

formula means the kinds and amounts of the ingredients used in the mixture. Mixtures of the same analysis may be made with different constituents, or with the same constituents in different proportions. Thus two given mixtures may secure all their nitrogen from nitrate of soda and sulphate of ammonia but in various proportions, and another may include these and one or more other sources of nitrogen. Usually at least part of the nitrogen is supplied from an organic form and it is commonly thought that this proportion should be liberal on very light soils.

Differences in the price of the same nutrients in the various constituent materials are reflected in different costs of producing mixtures of the same analysis from various formulae. With the many available materials an endless variety of formulae is conceivable and many are practicable. A formula with superior materials, or materials that are especially adapted to the crop and the conditions, may prove more valuable than some others. However, the difference in results, between competing commercial brands, as well as among home-mixed fertilizers of corresponding analysis, is usually insignificant.

Home mixing of fertilizers.—It is generally more convenient and satisfactory to buy ready mixed complete fertilizers and have them ready at hand for the rush of planting. A saving of a few dollars a ton, however, often may be effected by home mixing, especially when the ingredients can be bought in car lots and the mixture is applied promptly to avoid the expense of a conditioner. The grower knows exactly the kinds and proportions of the ingredients in the fertilizer and can modify these, or the ratio, to suit his conditions.

HOME CALCULATION OF FERTILIZER FORMULA

	Nitrogen	*Phosphoric Acid*	*Potash*	*Typical Cost of Materials Retail 1939*
Desired analysis in per cent	5	10	5	
Pounds required per ton	100	200	100	
Materials required:				
200 lbs. 16% nitrate of soda	32			$ 3.83
300 lbs. 20.5% sulphate of ammonia	61.5			6.39
1000 lbs. 20% superphosphate		200		10.24
200 lbs. 50% muriate of potash			100	3.56
1700 lbs. total per batch	93.5	200	100	24.52
Approximate actual analysis	5.5	11.7	5.9	(Mixing) .50
Equivalent to 2000 pounds	4.6	10	5.0	25.02

In mixing fertilizers for your own use, exact conformity to the desired analysis and close uniformity from bag to bag are not neces-

sary. Thus a 1-2-1 ratio to analyze about 5-10-5 may be required. Perhaps nitrate of soda or sulphate of ammonia, 20 per cent superphosphate, and 50 per cent muriate of potash are to be used. A convenient form for the calculation appears on the last page. The resulting mixture is close enough to 5-10-5 for practical purposes. No one knows precisely what analysis he needs. Weighing of components is avoided because the quantities are in multiples or halves of full-weight original bags. Filler or conditioner is not required because mixing can be done at the time of application.

To illustrate the simple modification of ratios in home mixing, two standard 167-pound bags of 20 per cent superphosphate added to the above batch would increase the weight to about one ton and the actual analysis to approximately 4.5-13-4.9, which is nearly in the ratio of 1-3-1, or the commercial 4-12-4. Formulae including other materials may be calculated in the same way. As a rule the nitrogen is supplied in two or more forms of different availability.

In mixing fertilizers for home use there is little risk of serious loss of ammonia, reversion of phosphorus to unavailable forms, formation of hard lumps, or other difficulties, if precaution is taken to add no caustic lime-carrying materials and to apply the mixture promptly to the soil. When mixing for immediate application some growers include pulverized limestone, preferably of the dolomitic type, as a means of neutralizing the acidity of sulphate of ammonia or of providing light liming without the expense of a separate operation.

Mixing fertilizers is a simple operation. The laborers should be provided with scoop shovels, and a medium fine sand screen, not less than 3 feet wide and 5 feet long, mounted on a frame that may be propped up at any angle to the floor. The proper amounts of the several ingredients are spread in a broad pile, each ingredient in a separate layer. The material used in the largest amount should be at the bottom, with layers of the other ingredients spread over the entire pile, not dumped at one side. The sand screen is placed near the pile at an angle of about 45 degrees to the floor. Two men, one at each side, shovel the fertilizer up on the screen. The finer particles pass through the screen, and the lumps roll to the bottom where they can be crushed with the shovels. After the pile has been screened it should be shoveled over twice. After mixing, the material may be hauled out in bulk or bagged in convenient amounts. Approximately 100 pounds are placed in each bag, which usually can be managed by weighing a few bags and counting the shovelfuls required. Bags containing uniform weight are desirable in checking rates of application. Mixing and re-bagging should not cost more than 50 cents a ton. Concrete mixers are convenient and economical for mixing large amounts of fertilizer, and sometimes are operated

on a barn floor through which the mixed fertilizer can be dumped directly into a wagon or truck and taken to the field.

Comparing fertilizer quotations.—The cost of competing fertilizers by the ton is not a proper basis for comparison. Comparable prices of carriers of one element may be computed by dividing the price per ton including transportation to the farm by the figure representing guaranteed analysis. The quotient is the delivered cost per "unit," that is, one per cent of a ton, which is 20 pounds, of nitrogen, phosphoric acid, or potash as the case may be. For example, unit costs of nitrogen would be $2.50 in nitrate of soda (16 per cent nitrogen) at $40.00 per ton, and $2.00 in sulphate of ammonia (20.5 per cent nitrogen) at $41.00 per ton. The phosphoric acid in 20 per cent superphosphate costs $1.00 a unit when the price is $20.00 a ton. With muriate of potash (50 per cent potash) at $40.00 a ton the unit cost would be 80 cents, at $50.00 a ton it would be $1.00. When comparable costs are available the next step is to consider the probable relative efficiency under the conditions of use as well as the residual effects.

Figures indicating relative worth of fertilizers supplying more than one element can be easily calculated as follows: multiply the guaranteed percentage of nitrogen by an assumed unit price (see last paragraph), do the same with the percentages of phosphoric acid and potash, using fair unit prices for each, and total the products of the three multiplications. In comparing results of the calculations for competing brands consideration must also be accorded to differences in quality of ingredients, physical condition and integrity of the manufacturer.

APPLYING FERTILIZERS

Rates of application.—In planning how much fertilizer to apply it is necessary to consider the effect of the soil on the fertilizer as well as the effect of the fertilizer on the crop, and this is especially true with phosphorus, also with nitrogen under conditions that may cause depression of nitrates. It sometimes happens in highly acid or alkaline soils, especially when the supply of organic matter is low, that small amounts of fertilizer phosphorus produce little or no increase in yield, principally because much of the element supplied is quickly converted to unavailable forms. In such cases larger applications may be more profitable on account of efficiency in utilization of the phosphoric acid supplied in excess of the increment first subject to fixation. The main remedy is to improve the status of the soil with organic matter and lime, but even with good management there may be considerable fixation of phosphorus in the heavier soils.

Another consideration is to adjust the rate of application in accordance with potential income from the investment. The law of diminishing returns quickly becomes operative when too much is spent for fertilizers on crops of small maximum value to the acre. But very liberal expenditures can be made when the crop is normally of high market value and gross feeding habit, such as celery, cauliflower, or onions.

FIG. 35.—Fertilizer is applied speedily by broadcasting, a suitable method for many crops.

Rates of application as suggested will be on the basis of the most commonly used mixtures, which contain about 20 or 25 units, such as 5-10-5, 4-12-4, 4-16-4, and 4-8-8 or 5-10-10. Keeping in mind that fertilizer ratios must be appropriate to the crop, soil, and season, normal rates of application range from a minimum of about 300 pounds to the acre for peas, beans and sweet corn, when all the fertilizer is placed in bands near the seed, to 1000 or 1500 pounds to the acre broadcast for the salad crops, cole crops, root vegetables, and bulb crops. A ton or more to the acre may be profitable with certain very intensively grown vegetables on sandy soils or peat. Usual rates for the solanaceous crops are 500 to 1000 pounds, for the cucurbits 400 to 800 pounds, and for sweet corn 300 to 600 pounds to the acre. As a rule very early plantings are fertilized one-half heavier than plantings made after the soil becomes warm. Band or row applications at the time of planting usually are not more than half so heavy as broadcast applications that are harrowed

in before planting. [See page 508 for tabulation of fertilizer recommendations.]

Broadcast applications.—In general, fertilizers are broadcast for crops that are planted in close rows and whenever relatively large applications to the acre are made. Such applications are helpful in establishing and maintaining a high level of fertility. In broadcasting it is customary to distribute the fertilizer after the land has been plowed and roughly leveled. The fertilizer will then be worked into the soil by harrowing in preparation for planting. Uniform distribution is important. Fertilizer or lime spreaders and grain drills are used, and in the garden the fertilizer may be distributed by hand. Some growers consider it advantageous to apply one-half the fertilizer broadcast and the other half in the row.

Virginia Truck Experiment Station

FIG. [illegible].—Fertilizer placement with kale. Rows 4 and 5, in band 2 or 3 inches below seed. Rows 6 and 7, in two bands, 2 inches to each side, 2 or 3 inches below level of seed.

Row applications generally are most effective when the amount of fertilizer is only a few hundred pounds to the acre and such amounts, when properly placed in relation to the position of the seed, sometimes produce as large crops as twice the amounts broadcast. They are especially useful when maximum immediate return is required from minimum expenditure. However, row applications

in which the fertilizer comes in contact with the seed, directly above or below, or extremely close to it, often depress yields; poorer results may be secured from the heavier application on account of proportionate increase in injury to the seed or the young plant. In all cases of row fertilization it is extremely important to prevent contact or close proximity between fertilizer and seed, or roots of transplants.

Band placement.—There is much evidence that fertilizer is most efficient when placed in the soil in narrow, parallel bands on both sides of the row at a distance of one to two or three inches and slightly below the level of the seed. Increase in yields from such placement may be explained, in part at least, by three factors; reduction or elimination of injury to germination, strong early growth secured by having ample fertilizer quickly available for the young plants, and slower reversion of phosphorus with restriction of the fertilizer surfaces exposed to the soil.

Fig. 37.—Position of seed or plant with fertilizer placed in bands, the most effective method for many conditions.

Suitable attachments for corn, bean, and pea planters will lace the fertilizer as suggested (p. 345). The best potato planters re equipped for correct placement of fertilizer (p. 410), and may e used also to excellent advantage in making up band fertilized ows for tomatoes, cucurbits, or other crops. By adjusting the cov-ring discs the rows may be left open or closed, as required and either evel or ridged for planting. Danger of fertilizer injury is les-ened by preparing the rows several days before planting. Trans-lanting machines also may be had with band fertilizing equipment.

On some soils the most effective utilization of liberal amounts of ertilizers for the more or less widely spaced row crops is obtained y dividing the application and using band placement with one-half he fertilizer as an initial application and the other deposited two or hree weeks later by means of a cultivator-mounted distributor.

International Harvester Co., Inc.
FIG. 38.—Side-dressing with fertilizer is an effective practice for certain conditions, especially on porous soils. Cultivator-mounted distributors for either tractor or horse machines are a convenient means of application.

TYPICAL FERTILITY PROGRAMS

The setting-up and observance of a definite program of maintenance of organic matter and of fertilization, with appropriate modifications as new conditions arise, is the best insurance against the malnutrition that too often insidiously limits yields and saps profits before the deficiency becomes apparent and is recognized. It is the purpose, therefore, in outlining a few typical soil fertility programs, to provide a background for consideration of the individual problem of maintaining high degree of productivity.

On dairy farms where vegetables are grown for sale it is standard practice to apply about 10 tons of manure to the acre on legume sods any time after the hay has been harvested. Plowing for early crops is done at any convenient time during late fall or winter, or for later crops before spring growth or weather dries the soil. Lime is applied as required, usually before the legume. Fertilizer applications for the vegetable crops range from a few hundred pounds of superphosphate alone, or of 4-16-4 or 4-12-4, for sweet corn, peas, and beans, to 500 to 1000 pounds of superphosphate or appropriate mixtures for potatoes, tomatoes, and cabbage. A larger

proportion of potash may be profitable on the lighter soils. Large economical yields are often secured.

Extensive truck farming without manure, but in rotation with a fully grown legume about every third or fourth year, and with over-winter non-legumes at other times, may be carried on successfully provided lime and fertilizers are used as may be necessary to assure good vegetable crops and also large growth of soil improving crops to plow under. With good management, yields may be almost as high as with manure and may be more economical than if manure is purchased. For the various crops, fertilizer applications usually range up to 1000 pounds to the acre of 4-12-4 or 5-10-5, with more potash for the root crops and sandy soils. On typical coastal soils the ratio for many crops approaches 1-1-1 or 1-2-2 and the application may be as great as a ton to the acre of such analyses as 5-8-7, 7-6-6, 4-8-8 or 5-10-10.

Intensive truck farming in which one or more cash crops may be grown every year, very often is carried on with green manures over winter and with the application of animal manures for critical crops, or when there is not sufficient time for a green manure or the amount of organic matter produced for plowing under has been small. A few growers, usually on loam soils, may crop very intensively without manure and secure good yields, but in all such cases intensive use is made of strongly growing green manures at every possible opportunity. Fertilizer, frequently in a 1-2-1 or 1-2-2 ratio, is used very liberally, perhaps with considerable additional nitrogen on both vegetable and green manure crops. The lime requirement receives close attention.

Intensive market gardening in which all the land is occupied with vegetable crops from early spring until late fall, with little or no opportunity for green manuring, requires heavy applications of animal manures. An application of twenty tons to the acre each year is probably as little as will assure the great friability of soil and the very quick, large yields necessary. In addition, lime, superphosphate, fertilizers in 1-3-1 and 1-4-1 ratios, and quickly acting nitrogen top-dressings may be employed. When the close succession of cash crops is broken to grow a green manure, the application of animal manures may be reduced one-half or omitted for the following crop. Over-winter cover crops, although time may be insufficient to make much growth, will check losses from leaching and add some organic matter.

The fertility program on muck soils is concerned primarily with supplying the mineral elements. Commonly used fertilizer formulae are 0-10-10, 4-8-12, and 3-12-18. These typical muck soil ratios may be noted as 0-1-1, 1-2-3, and 1-4-6 and are commonly used for onions, celery, and root crops, respectively. Of course,

it is understood that age and other differences of muck soils will necessitate variations; for example, that nitrogen should be included for onions. Lettuce may be served better by a ratio of 1-2-2, or even 1-2-1, as it seems that too much potash results in tip burn. Rates of application often are 1000 to 1500 pounds to the acre, sometimes more. Correction of soil reaction may be required, and it may be as necessary to plow very deeply or apply sulphur to acidify slightly a new muck containing marl as it is to apply large quantities of liming materials to very acid mucks (p. 249). Vegetable crops usually succeed over a wider range of soil reaction on mucks than on upland soils.

Appraising the fertility program.—It is unlikely, in establishing a soil fertility program, that all important factors will be foreseen and appraised correctly. Therefore, achievement of high efficiency in soil management is dependent upon frequent appraisal: regular tests for lime requirement; close observation of responses in rate and character of growth of both tops and roots; notation of yields and their trends, and omission and modification of the customary fertilizer application on an occasional strip or row for comparative purposes.

The so-called rapid tests of fertility may prove especially useful in vegetable growing where intensive methods sometimes involve startling situations and problems in soil management. It should be understood that chemical measurement of the nutritive resources of the soil involves a complexity of matters that make the result an approximation at best. When the tests are applied by a trained person, and interpreted with experience with the peculiarities of the particular soils and crops, fairly trustworthy deductions can be made.

Chemical tests of leaves or other parts of plants during the growing season may reveal the nature of apparent nutrient deficiency.

In conclusion it is urged that the absolutely fundamental requirement for a successful vegetable growing business is a sound fertility program, which can be achieved only by thoughtfully coordinated use of organic matter, lime, and commercial fertilizers. The next step is the finesse of specific fertilization to fulfill the exact nutritional demands of different crops, different varieties of the same crop, and different weather or seasons. The table (p. 508) should be interpreted as a guide rather than as specific recommendation.

VII

PLANTING

PREPARING THE LAND

In preparing soil the aim is to provide conditions as favorable as possible both for the start and for the later development of the crops to be grown. This must be accomplished efficiently and economically. One or more additional or incidental purposes may be served, such as to incorporate organic matter, lime or fertilizers with the soil; to control weeds, and to combat insects or diseases, as by timely and thorough plowing under of infested crop residues. Both yields and profits depend in no small degree upon the adroitness of the grower in suiting tillage operations to particular soil conditions and crop requirements.

Timeliness in preparing soil is of importance on two accounts: (1) Thorough preparation is accomplished with fewer operations, the draft is lighter, and wear of implements is reduced when the operation is accomplished at a favorable degree of moisture. The soil works most easily and with best effect when a handful may be pressed into a ball that will hold its shape well but crumble readily. (2) Delay often results in the crop reaching the market too late for best prices or in losing the opportunity to plant a succeeeding crop. Good management demands sufficient power for the acreage, either from animals or engines (p. 61). And output of work must not be impeded by lack of implements, or by those poorly adapted to the work.

Choice of plows and harrows.—If the vegetable grower could have but five implements these should unquestionably be, for most conditions, plow, disc harrow, spring-tooth harrow (spike-tooth for light soils), cultipacker, and plank drag. With them practically every soil fitting problem can be solved. In addition he should have a Meeker harrow if the soil is not stony.

Among plows the common 14-inch-bottom walking type is most commonly used with horses or mules. Two-way sulky plows are popular because all the furrows may be turned in one direction. Twelve-inch plows are too small to cover the refuse or manures that frequently must be turned under in vegetable gardening. Most tractor plows carry 14-inch bottoms. The large plows with 16-inch or 18-inch bottoms, jointers and rolling coulters, however, are particularly efficient in cleanly turning under heavy growths.

Disc harrows are universally employed. They work to best ad-

vantage in land that is not very stony, but are useful even among stones because fewer are worked to the surface than with springtooth harrows. The heavy discs, with blades 20 inches or more in diameter, are very effective in cutting up trashy residues, animal or green manures, and working them partially into the soil before plowing. Plowing sometimes may be dispensed with through heavy discing under favorable conditions, as in preparing for spinach following beans, or wherever the soil is in good tilth and very deep working is not required. After plowing, discs serve to pulverize and stir the soil to a considerable depth and are very effective in chopping up sods and clods.

FIG. 39.—Disc, pulverizer, and plank drag preparing a heavy soil smoothly.

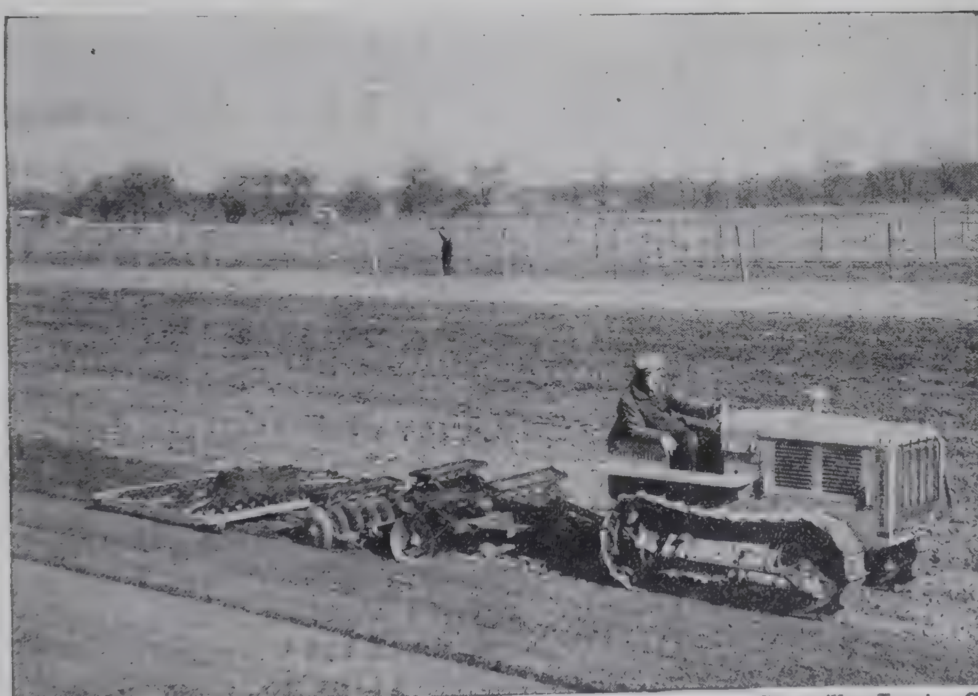
Springtooth harrows are especially useful in loosening the soil, killing weeds on land that has been plowed for some time, and mixing fertilizers and lime into the soil. In very stony land they are the only harrow that will penetrate deeply.

The cultipacker, or corrugated roller, is of incomparable efficiency in crushing clods thrown to the surface by harrows and is effective in firming and smoothing the soil to conserve moisture.

The plank drag, or float, is an inexpensive home-made implement that is as valuable for some purposes as any that could be purchased. It is widely used for firming and leveling after plowing, for crushing clods, and to produce a fine, smooth surface to receive small seeds or delicate plants. On land containing stones the drag is decidedly the best implement for smooth finishing. It should

be noted that heavy soils which have been dragged pack and crust more after hard rains than those finished with a harrow, and that it may prove undesirable to produce a surface smoother than that demanded by the requirements of the seeds or plants. On this account, and to avoid unnecessarily heavy draft at times, it is an advantage to have both light and heavy drags. Drags are most effective in crushing clods when the soil is slightly dry.

Meeker harrows, which have many small flat discs mounted on four rollers with an adjustable leveling plank in the middle, are practically indispensable for fine finishing and should be used almost exclusively for that purpose. The Meeker harrow takes the place of the hand rake.



Caterpillar Tractor Co.

Fig. 40.—Adequate power and suitable implements are required for thorough preparation and timely planting. The meeker harrow is especially useful in finishing light soils.

Spiketooth harrows are used more generally than their efficiency justifies but they are good levelers in light soil. They work only to shallow depth and tend to push clods aside rather than pulverize them. They are very light in draft, however, and are useful where it is desired to mix fertilizers, to break light crusts, perhaps even after planting, and to kill germinating weeds.

TIME AND DEPTH OF PLOWING

Fall plowing is practiced extensively by vegetable growers. It is considered especially desirable on the heavier types of soils. The following advantages may be enumerated: (1) If the land is hilly or rolling, rough unbroken furrows will collect more water and thereby reduce erosion, and, if harrowing is done as soon as possible in the spring, there will be a maximum reserve of soil moisture to meet crop needs; (2) the physical condition of many soils is improved; (3) organic matter plowed down in the fall becomes better decayed and more valuable to the spring crop; (4) land plowed in late fall dries off more quickly in the spring, therefore may be harrowed and planted earlier; (5) fall plowing relieves the pressure of the spring work; (6) it exposes many insects to destroying agencies (p. 163). Fall plowing in the North, where the land is sealed by frost during the winter, is regarded as more desirable than in the South where the loss from leaching must be considered. It is especially advantageous to plow heavy sod lands in the fall.

As a rule it is not objectionable to plow wet soil in late fall or winter when it is certain to freeze thoroughly before drying.

When plowing is deferred until spring it should be completed at an early date. This is important from every standpoint. No greater mistake can be made, however, than to plow before the ground is dry enough. Every experienced farmer well knows the evil effects of such a practice. Where early plowing must begin as soon as possible, many gardeners prefer not to spread stable manures until the ground is ready to plow, because such a mulch greatly retards the evaporation of soil moisture.

Most garden crops thrive best in soils which have been ameliorated to a considerable depth, so that deep plowing is favored by successful vegetable growers. No soil should be plowed deeper, however, than the character and depth of the top soil will permit. The intermingling of a large portion of unproductive subsoil is always detrimental to garden crops.

The subsoiling of garden soils has been advocated by many writers, but it is seldom practiced and is of doubtful utility for average conditions. Under special conditions it may be valuable.

Factors determining the time for plowing green manures have been discussed (p. 90).

Procedure after plowing.—The first consideration is to prevent excessive drying by roughly leveling and firming the soil as soon as it becomes dry enough to work. An enormous amount of moisture is lost when freshly plowed land is exposed to the sun and wind for a long interval before leveling, and thorough pulverization becomes impossible when the soil dries too much. Often no more

land should be plowed than can be worked once the same day. A drag or cultipacker should follow the plow as soon as the soil is dry enough to crumble readily. When the soil is not too wet a light drag or packer can often be attached as an outrigger behind the tractor plow.

The next operation may be distribution of lime and of fertilizer that is to be broadcast. Discing or springtoothing in one or both directions, as required, may follow. The efficiency of the implements in leveling the soil is often increased by operating them obliquely across the field rather than directly with or across the direction of the prior working. Under favorable conditions one or two harrowings, perhaps with timely cultipacking or dragging, will be sufficient preparation for the coarser crops. Additional discing or springtoothing, possibly followed by cultipacking, and finally Meeker harrowing or light dragging, will fit the soil for small seeds or plants. With powerful tractors it is common to hitch two, three, or four implements in tandem, often cultipacker, disc harrow, and Meeker harrow or light drag, and prepare the land at one passage of the train. If the soil is hard the disc should be operated ahead of the packer. Loss of moisture is less when the soil is fitted quickly with a short interval of time between the several operations.

Degree of soil preparation.—Although thorough preparation is necessary to eliminate air pockets in the soil, pulverize clods, and level the surface, it can be overdone. If moist soil is worked more than necessary, serious packing may occur beneath the surface layer that is stirred. Extreme pulverization of dry soil provides favorable conditions for erosion by wind or water and for crusting, baking, and cracking during bright weather following dashing rains. A granulated condition is ideal.

Adapting soil preparation to the crop and the season is a matter of considerable importance. In general, peas, beans, and corn, which are planted an inch or two deep, are suited best by soil that is not very compact and that is loose and not too smooth at the surface. The root crops, of which the small seeds must be planted shallowly, require soil that is evenly pulverized from the furrow bottom upward, and is fine and firm at the surface. Spinach and lettuce, particularly in summer or early fall, demand rather firm, fine soil that will assure a steady rise of moisture to the level of the seeds. If the larger plants, such as cabbage and tomato, are to be set by hand it is desirable to have fairly firm soil up to the bottom of the planting furrow and rather loose soil above. That may be accomplished by preparing the soil to a good depth some time before planting, and harrowing only a few inches deep just ahead of the planting crew. It is more convenient to set the smaller comparatively stemless plants, such as lettuce, beet, celery, and onion, in soil

that is moderately firm at the surface, as well as very smooth and even. For potatoes the soil may be worked from the bottom up, as a rule with a springtooth or disc harrow, and no more than is necessary to eliminate large clods and provide a deep fairly loose seed bed. Much pulverization is undesirable.

As an example of adapting preparation to the season of planting, peas planted in March or very early April on loose, coarsely prepared, and trashy soil usually germinate and grow well in spite of wet, cold weather; on the other hand, peas in fine, compact soil are very likely to rot. In general the soil should be relatively loose and coarse for extremely early plantings; very firm and quite fine in texture for late summer plantings. In the first instance air will be introduced into the soil to dry and warm it; in the second, air circulation will be restricted so as to conserve moisture and assure an adequate supply in the upper layers of soil.

Weed control by soil preparation is practicable to a considerable extent and is especially effective when the soil can be vacant some time before planting. In brief, the procedure consists of firming the soil with drag or cultipacker to encourage germination, harrowing it a little later to kill the tiny weeds that have started, and repeating the process once or more, if time is available. Each succeeding harrowing should be slightly shallower than the preceding one to avoid stirring up a new lot of dormant weed seeds that may germinate if moved near the surface.

Efficiency in preparing the soil depends equally upon adaptation of the implement to the work to be performed and upon the moisture content of the soil at the time of operation. This relationship has been suggested previously but warrants emphasis. If the soil is worked when too wet it becomes packed or puddled, a compressed structural condition that results in the soil drying into hard, unmanageable lumps that may persist for a year or more in heavy soils, unless frozen out sooner in cold climates. If the soil is worked too dry, effective pulverization is not secured and many clods remain unbroken. In addition there is the economy of working the soil as far as possible at the most favorable degree of moisture. Then only half as many operations are likely to be required, plow parts will last longer, and the draft will be much lighter. With a tractor it is often good business to operate long hours, or even day and night, in order to complete the work under optimum conditions, or to be sure the planting schedule will not be delayed by unexpected inclement weather.

SOWING IN THE OPEN

Requirements for germination are oxygen, proper temperature, and moisture. Skillful management and preparation of the

soil are necessary to provide the favorable conditions for germination that assure consistently good stands of plants under the adverse weather conditions that often prevail. Many kinds of seeds cannot germinate properly in heavy compact soils that are deficient in humus. Air can scarcely enter such soils and they crust badly. The larger seeds may succeed under adverse circumstances but most of the vegetable seeds demand soil of the best physical condition and fine texture. Failure to get a good stand of plants is often due to clods and coarse particles which cause the soil to dry out quickly and prevent it from coming into direct contact with the seeds. This is a matter of prime importance. In a well-prepared seed bed each particle is surrounded with a film of water and, when a large number of these are in contact with the seed, ample moisture is supplied for germination. To prevent injury to the germinating seed the fertilizer must be applied to avoid direct contact (p. 111).

The moisture supply for germination.—Adequate moisture may be assured in various ways. Fall or early spring plowing is usually a great advantage in conserving moisture. Unnecessary loss of moisture after spring or summer plowing can be avoided by prompt compacting and leveling. If the sowing date is rather late in the season, when the soil is likely to be dry, sufficient moisture usually can be conserved by plowing early and by harrowing very shallowly at appropriate intervals to keep down weeds and maintain a soil mulch. Soils which have received heavy annual applications of manure are seldom too dry for the successful germination of seeds.

Special moisture-conserving measures, which are practicable on a small scale, are to mulch the soil with straw or manure, the coarse particles of which are removed by raking immediately before sowing, and to mulch after sowing with any kind of litter, burlap, cloth, screens, or paper, which are removed when sprouts begin to appear above ground. Even on a large scale it is practicable and effective in dry times to mulch each hill of cucurbits with a forkful of straw, which is partially removed or parted as the plants push through the soil.

Another popular special practice in some districts is to sow small seeds about one-half inch below the surface of carefully leveled soil and, in covering, throw up small A-shaped ridges directly over the seeds. This may be done by small discs or hillers attached to the drill. When germination is well started the ridges are leveled with a plank drawn edgeways, with various light drags or scrapers similar in appearance to a hotbed sash without glass, or with rakes. By this system moisture is provided for germination, crusts are broken to facilitate emergence of the seedlings, and the early development of weeds is checked (p. 122).

Irrigation is employed extensively to assure quick and certain germination. Under some conditions it is good practice to irrigate before sowing, to harrow lightly as soon as the soil is workable, and to sow at once.

The risk of excess moisture at some seasons may be avoided to a degree by leaving the soil in a rough, deeply-loose condition until the day of planting.

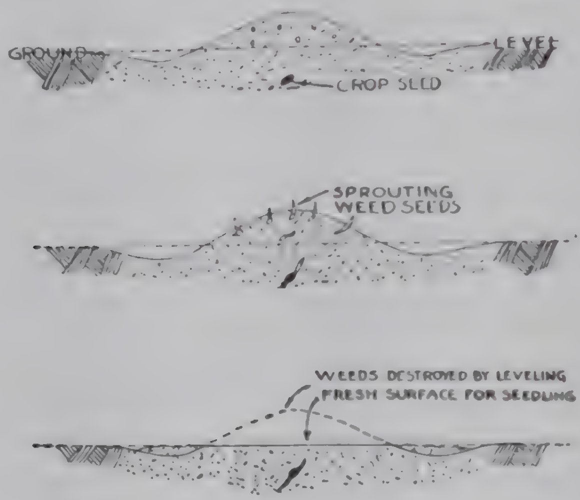


Fig. 41.—Method of ridge covering and later leveling sometimes used for low cost control of early weeds in carrots and other crops with slowly germinating seeds. Close observation of the progress of germination and timely leveling are necessary.

When to sow.—Experience counts for more than anything else in determining the proper dates for sowing different kinds of seeds. A great many factors must be considered; nature of the plant, length of season, average date of first and last frost, prevailing weather, fertility in its effect on the time to maturity, but one of the most important is market conditions. When will a given crop be most likely to command the best prices, and how many weeks will be required to get the crop ready for that particular time? In making succession plantings to furnish a continuous supply, a schedule based on experience is the best guide, or a new sowing may be made when seedlings from the prior one begin to appear above ground.

Lettuce, onion, beet, carrot, radish, spinach, pea, cabbage, and other cole crops may be sown as soon in the spring as the ground can be prepared. The seeds of corn, bean, cucumber, melons, and squash soon rot in cold damp soils and can not be planted in the open with certainty of strong germination until the ground is warm

and there is little or no danger of frost. It may be worth while, however, to risk limited earlier plantings. A planting guide will be found in the Appendix (p. 507).

It is usually better to sow after rain rather than before, if it can be managed, and this is especially true in the heavier soils. The soil may bake after a rain, and a hard surface crust is fatal to the germination of delicate seeds. Such crusts exclude air, which is essential for the processes of germination, and make it difficult for the tiny plant to force its way through the soil to the light. If heavy rains fall soon after sowing, the crust can often be broken to advantage by rolling or raking as soon as the ground is dry enough. It is usually desirable to sow in freshly stirred soil, because germinating weeds have been destroyed and moisture conditions are uniform.

Quantity of seed to sow.—Many questions must be taken into account when determining the proper amount of seed to use on a given area. Among them may be mentioned: (1) Vitality of the seed. This should be previously determined (p. 15), and the rate of sowing regulated accordingly. (2) The date of sowing. It may pay to take chances in planting some crops, such as beans and sweet corn, before the ground is warm enough to make certain of a high percentage of germination. By using seed freely a good stand may be secured. (3) The physical character of the soil. More seed should be used in heavy soils, because the percentage of germination will be less than in light soils. (4) The size or vigor of the young plants. Carrot and parsnip seedlings are very delicate, and many may be lost before they are well started. Therefore the safe practice is to insure a good stand by fairly heavy seeding. (5) If seedlings are to be transplanted, the time when this work will be done should be considered. The seed may be sown much more freely if transplanting is to be done early. (6) The cost of thinning. It is rather expensive to thin some crops. For example, the thinning of spinach or onions is slow and tedious and therefore great care should be taken to sow the right amount of seed. (7) Ravages of insects. Insects are often very destructive to certain plants, such as melons and cucumbers, and by using plenty of seed there will be greater certainty of saving enough plants to make a satisfactory stand. It generally pays to use seed freely, when adverse conditions may be encountered, and to thin when necessary. Usual rates of sowing are tabulated in the Appendix (p. 506).

Depth of sowing.—There are no infallible rules to determine the proper depth for sowing. The soil covering may be regulated by the diameter of the seed—that is, by making the covering two, three, or four times the diameter of the seed. This may be of some value when sowing in the greenhouse or hotbed, where moisture and soil conditions are under control, but it is likely to be misleading

when applied to field conditions. In light, sandy soils the depth might be several times as great as in heavy soils. Summer and early fall sowings require greater covering than do early spring sowings, because the surface layer of soil is drier, and it is necessary to place seed at a greater depth to secure the necessary amount of moisture. Some of the smallest seeds, such as celery, are often pressed into the soil. A very slight covering is sufficient for many seeds when the best conditions are provided. [Consult the chapters on the culture of the various classes of vegetables to obtain more definite information on proper depths for planting.]

Seed treatment.—Disinfectant and protective treatments, as previously described (p. 22), are essential insurance with a number of crops.

Soaking seeds.—The soaking of seeds before sowing may be the means of hastening germination a few days, but such treatment may prove detrimental unless it is carefully managed. Most growers never soak any kind of seed before sowing. The practice is most common with asparagus and celery seed and is described in later chapters.

Broadcasting or drilling.—Some crops may be grown from seed sown broadcast, but this is impossible with plants requiring frequent cultivation. Many growers broadcast turnip and spinach seed, but drilling is more common practice for the latter. Broad-

Fig. 42.—The one-row drill is indispensable for many purposes.

casting is not without merit. It may be done very quickly and inexpensively, and the individual plants often have a better chance for full development than when the seed is sown by a drill. This is particularly true with seedlings that must be transplanted. Some

growers of late cabbage plants always broadcast the seed, because they claim that the plants are stronger and stockier than those grown in drills without thinning. Most of the arguments, however, are in favor of drilling, and the advantages over broadcasting may be enumerated as follows: (1) Weed control is extremely difficult in broadcast plantings. (2) It is easier to thin when the plants are in rows than when they are scattered. When properly sown or thinned they should be just as strong as when grown from seed sown broadcast. (3) The seed is sown at more uniform depth and less seed usually is required. (4) In stiff soils the percentage of germination may be greater, because the seedlings assist each other in their effort to reach the light. (5) Crops in rows, spinach for example, usually may be harvested with less expense.

Sowing in the open ground.—Sowing by hand is practiced commonly by home vegetable gardeners. Lines or markers should be used to secure straight rows. The furrows may be opened with a small shovel of the wheel hoe cultivator, or with a rake or suitable hand hoe. One of the best ways to make a shallow furrow for small seeds is to stretch a line and follow it with the back of the garden rake which will make a neater furrow than any other tool. The seeds should be distributed uniformly in the furrow. The furrows may be closed by using a hoe, rake or hand plow, the implement used depending upon the required depth of covering.

Seeders or drills are indispensable in commercial vegetable growing, because they do the work much better and more rapidly than

John Deere

Fig. 43.—For greatest economy, the size of equipment must suit the operation.

is possible by hand sowing. The seeds are deposited before the soil has had time to dry out; the depth of covering is uniform; the soil is compacted after sowing; the rows are straighter, and the seeds can be dropped in hills, if this is desired. Most makes of seed drills are satisfactory when properly used. A wheel hoe and a drill are sometimes combined in one implement, but the tool is not popular with commercial growers because of the time and trouble necessary to convert drill to wheel hoe and vice versa.

Some of the best garden seed drills regulate the rate of seeding by means of plates containing numbered holes of graduated size. Thus, the grower is enabled to regulate precisely the rate of seeding, to repeat exactly a certain rate when sowing again from a certain lot of seed, and to have all the units in a multiple row drill sowing at the same rate. It should be noted that the rate of seeding through a certain aperture is likely to vary greatly with different lots of seed of one variety or kind, with the speed of operation, and as a result of treatments of the seed. The instructions of manufacturers for sowing different kinds of seeds, at best, can be only general. The rate of distribution should be ascertained first on a floor or smooth

A. B. Farquhar Co., Ltd.

FIG. 44.—Four-row bean, pea, and corn planter with band fertilizing attachments. Two-row corn planters may be equipped with pea and bean plates and an inexpensive device to place the fertilizer at both sides of the seed.

driveway. Further adjustment may be necessary after the quantity of seed sowed in a few rows indicates the amount that is being used to an acre.

Peas and beans may be planted very satisfactorily by means of many garden seed drills, but it is difficult to secure a sufficiently light rate of seeding and uniform spacing of sweet corn with these machines. The ordinary corn planter, as used in general farming, however, is an excellent machine for planting peas and beans as well, when special plates and brush cut-offs are provided. Even cucumbers, melons, squashes, and beets may be planted successfully through suitable inexpensive plates in the corn planter. All such planters should be equipped with shoes or discs which will place the fertilizer in bands an inch or more to the sides and slightly below the level of the seed. Grain drills are commonly used to plant peas in drills for cannery crops and will plant in rows by running three tubes into one hoe or by stopping certain of the feeders.

Multiple row sowing speeds the operation and is a great advantage with large acreages. It is essential for multiple row cultivation because the rows can not be spaced perfectly equidistant and parallel with single row planters.

Firming the soil.—It is often an advantage to firm the soil after sowing. By this operation the seed is brought into close contact with the soil particles which furnish the moisture necessary for germination. Compacting is especially important in dry weather and in loose soils. Peter Henderson advocated "the use of feet" in market gardening. He often had men step foot over foot on plats of several acres where the rows were only 1 foot apart. The modern seed drill does the same work, but with less force, and in addition the roller is used sometimes for this purpose. The cultipacker may be used if necessary to firm the soil after planting peas, beans, or corn. Dense, compact soils and early sowings need little, if any, firming.

TRANSPLANTING INTO THE FIELD

Reasons for transplanting.—There are several important reasons why transplanting into the open has become a universal practice. (1) Earlier maturity of many crops may be secured by starting plants under glass. (2) Smaller expense is involved to cultivate, water, and control pests when the plants for large areas of some crops are concentrated in plant beds during the first weeks of their development. (3) Ideal conditions can be provided in plant beds for the growing of delicate plants, such as celery, which may fail to produce a full, even stand when sown under some field conditions. (4) The ground to be planted is often occupied with another crop, hence the necessity for growing plants elsewhere and having

them ready when the land is released. (5) Less seed is required when the plants are produced in the plant bed rather than in the rows where they are to mature.

Severity of transplanting.—Skilful growers rarely fail to secure a satisfactory stand, when transplanting into the open ground, and 100 per cent survival is not uncommon. When failure occurs it usually is attributable to soft or undersized plants, unfavorable condition of the soil, or improper workmanship. Mere survival is not sufficient. A severe check in growth almost invariably delays maturity, or causes prematurity, and reduces the yield. Rough pulling of plants, by which they are stripped of all soil and fine roots, exposure to drying sun and wind, crushing in baskets and subsequent heating, and indifferent setting are to be avoided. Good workmanship in setting plants requires no more time than do careless methods, if as much.

It is often an advantage to water dry soil before transplanting. Irrigation, however, is not available on many farms, so that good judgment and great care must be exercised to conserve the proper amount of moisture by suitable preparatory operations (p. 118).

The importance of proper preparation of soil, as described for sowing seeds, is equally applicable to preparation for transplanting. The severity of the operation is less apparent and recovery is quicker when the plant is introduced into hospitable soil.

Preparing plants for transplanting.—When the bed is watered thoroughly, about 24 hours before transplanting is done, the plants can be pulled or lifted with little injury to the root system. Careful lifting is usually worth while, though more labor is required than in pulling. A many tined fork or a spade is commonly used to lift or loosen plants grown under glass as well as in outdoor plant beds. In larger operations celery lifters, cultivator sweeps, or any mechanical device that will loosen the soil under the plants is an advantage. Late cabbage and related plants, however, usually may be pulled from very moist soil without serious root injury. Plants which have been lifted or pulled for transplanting should be protected as much as may be necessary to keep the roots moist and to prevent appreciable wilting. It is important to set plants as soon as possible after they are lifted.

To remove plants from flats, the flat is placed on edge, lifted, and jarred on the ground roughly enough to make the soil separate from the bottom. Then the plants can be removed with liberal quantities of soil clinging to the roots.

Puddling is dipping the roots in thick muddy water just before the plants are set. It immediately insures intimate contact between the roots of the plants and the soil. As a result the newly set plants begin at once to draw upon the soil moisture. One objection is that

a few diseased plants, for example cabbage affected with black-leg, in passing through the bucket of muddy water may become the means of infecting the entire lot. However, disinfectants such as corrosive sublimate may be introduced to prevent fungus distribution (p. 52).

Plants that are shipped long distances often arrive quite dry and dormant. Rather than plant them at once in that condition it is better to heel in, that is, distribute the plants closely together in small furrows with the roots of each in close contact with well firmed, rich, moist soil. To nurse the plants into active growth in a short period of time, shading may be desirable at first and water should be applied as required to maintain the optimum degree of moisture. When new white rootlets appear the plants may be set in the field.

When to plant.—A number of factors must be considered in determining the time for transplanting: (1) Are the plants ready for this operation? Although it may be the right date to transplant, additional time in the plant bed may be necessary to secure plants that will withstand conditions. (2) Has the time passed when there is serious danger of killing frosts? (3) Are the soil conditions all right—neither too wet nor too dry? (4) Are atmospheric conditions favorable? High humidity makes transplanting a more certain operation than low humidity. Cool and cloudy weather also is advantageous. If the plants have been properly grown and the soil is well prepared, transplanting may proceed all day, even though atmospheric conditions are not so favorable. The best times are just before or after a rain, but when many thousands of plants are to be set, the work cannot be done in the few hours when all conditions are exactly right. The latter part of the day is somewhat better than the morning, but this advantage is regarded as of slight importance by large commercial growers.

Planting dates are suggested in the Appendix (p. 507) and receive further consideration in the chapters on the different crops. In some instances planting dates may be advanced profitably by using plant protectors (pp. 478, 480).

Markers and marking.—Straight rows and spaces of uniform width are necessary in the successful management of a vegetable garden or farm. They not only look better but allow more rapid and thorough cultivation, with less annoyance to the operator, and are essential for multiple-row spraying or dusting. Efficient cultivation is especially difficult when narrow rows are spaced irregularly. Various peg or sled styles of markers may be purchased or made at home, or multiple row cultivators may be used, with all but a few of the shovels removed. In planting with machines, marking in advance is not usually necessary.

Depth to transplant.—The general rule is to set plants slightly

deeper than they were in the plant bed. It often is an advantage, however, to cover the stems up to the lower leaves of spindly plants or when there is danger of freezing or strong winds. In the South, fall-set cabbage plants are covered to the leaves, because this enables them to stand the winter with much less damage than if planted shallowly. Celery should not be covered deeply when planted, and deeply set lettuce will be subject to more rotting of the lower leaves.

Transplanting by hand.—Various tools are used for hand transplanting. Dibbers are especially valuable for light or sandy soils. The tool is thrust into the soil to the required depth with the right hand, and, after removal, the left hand places the plant in the hole. Then the soil is pressed to the roots with the hands, or heel, or the dibber is again thrust into the soil near the plant to press the soil against the roots. Trowels and spades may be used in a similar manner. Trowels and hoes also may be used in opening holes to receive plants. The fresh, moist soil should be pressed firmly over the roots. The small hand-operated planting machines work very well in fine soil and apply water at the same operation when desired. When transplanting during a protracted drought it may be desirable to place water in the holes before setting the plants. With good management in conserving moisture this is seldom necessary.

Transplanting plants grown in pots or veneer bands is discussed later (pp. 452, 453).

Field planting can be done very rapidly when the force is properly organized. In light soils dibbers or trowels may be preferred but the following plan, in general, is satisfactory under a great many conditions: One man makes furrows, which should not be opened faster than they are needed. About a dozen additional workers make a convenient force. Six of them drop plants and six set them. The foreman follows the workers and sees that the work is done properly. With this plan of organization, the crew will plant 40,000 to 50,000 plants in a day, more or less according to the spacing and soil conditions.

The most important single point in transplanting, by any method, is to have the roots secured firmly in the soil so that they may immediately begin to receive moisture by capillary movement.

Transplanting by machines.—Transplanting machines are in general use for setting cabbage, tomato, and other larger plants. Some models will do excellent work also, under favorable soil conditions, in setting celery, lettuce, and onion plants. Transplanting machines do the work better and more rapidly than is commonly done by hand, and, as a rule, at less expense. In many sections it is impossible to secure the necessary help at the time of planting and, in such localities, machine-planters are indispensable. They

are simple to operate, but a steady team or tractor and a careful driver are important factors. A narrow shoe opens the furrow, and the machine moves as slowly as may be necessary to enable the operators to place the plants in the narrow furrow. Plates or rollers close the furrow, pressing the soil very firmly to the roots and stems. Water may be used with each plant if desirable, a most important advantage under dry conditions when it would otherwise be impos-

H. J. Heinz Co.

FIG. 45.—The transplanting machine with watering attachment premits field planting even in dry weather. Band-fertilizing attachments also may be used.

sible to proceed without risk of losing many plants. By quick work the plants may be set about 12 inches apart with the ordinary transplanting machinery. Some growers, who do not have the celery-type of transplanter, set celery 12 inches apart and water the entire furrow bottom with the machine. Then an equal number of plants is set by hand in intermediate positions to make a final spacing of 6 inches. In large operations, two-row, tractor-drawn transplanting machines are sometimes used. In addition to increasing

the number of plants that may be set in a day, pairs of rows perfectly equidistant are thus planted so as to make two-row cultivation practicable. Transplanting machines may be equipped with attachments that will apply the fertilizer in the soil in bands alongside the row.

Care after transplanting.—Shading often is practiced in small areas after setting plants. It is not so essential, however, as generally supposed. Various articles are used, such as paper bags, shingles, small boxes, berry boxes, and boards supported by blocks of wood. Transparent plant protectors also are used which provide protection from wind and frost.

Watering by hand is often practiced to give plants a quick start or to prevent their death. Even on large areas the expense of applying a cupful of water to each plant is not prohibitive when the crew is well organized and the water is supplied without delay from the sprayer tank or from barrels on a wagon or truck. Loose, dry earth may be brushed over the wet spots to prevent drying and baking.

The use of sprinkler irrigation immediately after planting assures the growth of practically every plant. It should be noted that immediate irrigation, as soon as the planting crew is out of the way on a given strip, usually results in earlier, more uniform, and larger crops than are secured when the plants are permitted to wilt for even an hour on hot, windy days.

Starter solutions.—Nutrients in the transplanting water sometimes produce a remarkable response, especially on relatively infertile soils. On highly fertile soils significant response is less likely to be secured but ready accessibility of the nutrients may prove notably advantageous in promoting rapid early growth. The amount of nutrients that can be applied in the transplanting water is small, only enough to give the plants a start. The regular program of fertilization must not be neglected.

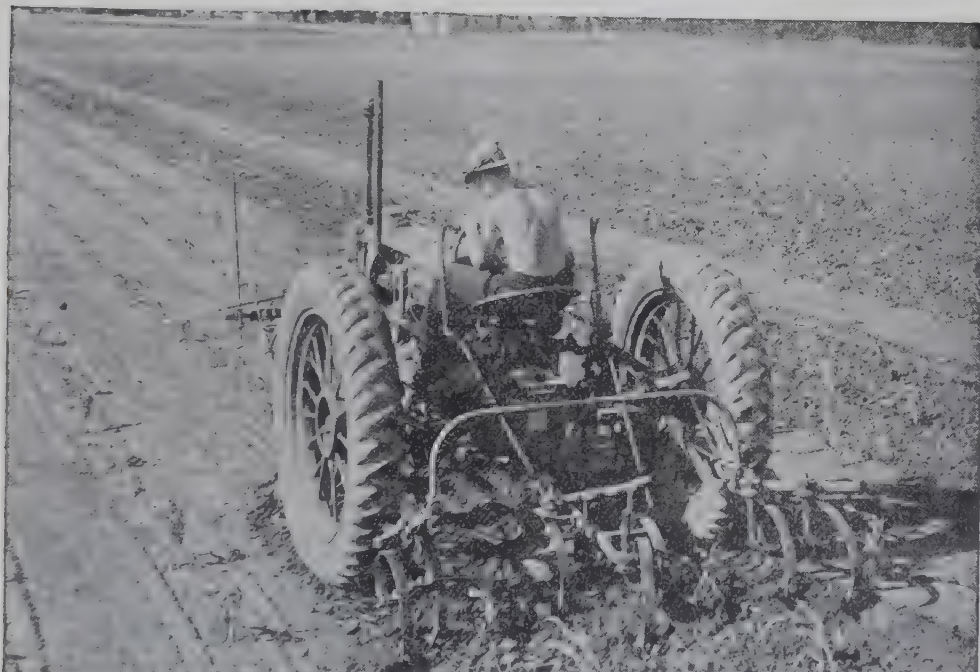
Many different materials or mixtures may be used. Two parts of ammophos 11-48 and one part of nitrate of potash gave excellent results at the Geneva New York Agricultural Experiment Station. Four parts of superphosphate 16-20 per cent, one part of calnitro and one part of nitrate of potash was among the best mixtures tested by the Department of Agricultural Research of the Campbell Soup Company. Two to four pounds of either mixture may be used in 50 gallons of water and applied at the rate of one-half to one pint to the plant.

A convenient method with the transplanting machine is to prepare a stock solution by suspending a sack containing 50 pounds of the mixture in a 50-gallon barrel of water. After the soluble material has gone into solution the residue may be discarded. Two to four gallons of the stock solution can then be added to the water at each filling of the 50-gallon tank on the transplanter.

VIII

CULTIVATION AND WEED CONTROL

TILLAGE of the soil after seeds have been sown or plants have been set is known as cultivation. The primary purpose of cultivation is to control weeds. Other effects of loosening the upper-most layer of soil may be beneficial or detrimental with different circumstances.



International Harvester Co., Inc.

FIG. 46.—Thorough control of weeds is essential to secure largest yields.

Necessity of weed control.—Weeds compete more successfully than most crop plants for moisture, nutrients, light, and air. If weeds are not controlled early in the development of the crop they may reduce the reserves of soil moisture and nutrients, nitrates in particular, so seriously that their later removal will not assure satisfactory yields. Crowding by weeds favors the development of many diseases because circulation of air is impeded and sprays cannot penetrate effectively. Almost without exception cultivation is the cheapest means of controlling weeds and is of necessity a nearly universal practice. However, quickly-growing crops, such as radishes, spinach, or peas, and occasionally others, are sometimes pro-

duced without cultivation on fertile land that is comparatively free from weeds.

Effects of loosening the soil.—A soil mulch, a thin layer of loose fine soil at the surface, is of value under some conditions in reducing evaporation, especially when it will remain effective for some time without additional stirring of the soil and on land with a tendency to bake and crack. It is well known, however, that cultivating soon after a light rain, or turning up moist soil during dry weather, increases greatly the loss of moisture by evaporation. Conversely, deep cultivation early in the spring may be beneficial in aiding the drying and warming of the soil.

It has been shown also that a soil mulch has little if any effect in conserving moisture in soil where crops with widely ramifying root systems are well established. With such crops, extensive damage to roots often more than offsets the favorable effects and reduces yield.

A very important effect of loosening the surface of the soil is to permit rapid absorption of dashing rains with more uniform moistening of the soil and consequential reduction in run-off and erosion. Improved aeration from loosening compact heavy soils encourages nitrification and other beneficial bacterial and chemical processes. Cultivating at the right degree of moisture incidentally promotes granulation of the soil. Finally, a shallow layer of dry soil at the surface is of definite effect in providing unfavorable conditions for the germination of weed seeds within that zone.

S. L. Allen & Co., Inc.

FIG. 47.—Frequent cultivation with the most suitable equipment keeps weeding expense at the minimum. Wheel hoes excel for some purposes.

Time and frequency of cultivation.—Timeliness is of primary importance. To cultivate, hoe, or weed at the right time may make the difference between profit or loss. Delayed or very infrequent cultivation often results in excess growth of weeds, unnecessary expense in hoeing and hand weeding, later maturing crops, and reduced yields. With some exceptions cultivation should begin promptly after sowing or transplanting, unless there is danger of frost injury which is likely to be more serious over freshly stirred soil than on well settled land.

It is a practical rule to cultivate as soon as the soil is dry enough after penetrating rains, and frequently enough to keep weeds thoroughly under control. Less expense usually is involved when tillage during early stages of growth is so frequent that weeds are destroyed while they are very small, even before they appear above ground. To avoid spreading disease, some crops should not be cultivated when the foliage is wet. In considering frequency of cultivation it should be noted that cultivation in excess of that required to control weeds is as likely to result in loss of moisture as in its conservation.

Depth of cultivation.—The first cultivation may be comparatively deep, if necessary, to loosen soil that has been compacted during the work of planting, or to aerate and dry the soil during early spring. Thereafter, relatively shallow stirring will minimize

S. L. Allen & Co., Inc.

Fig. 48.—One-horse cultivators are quickly adjustable to different conditions. They are especially useful in the market garden where many row spacings and sizes of plants are encountered in a day.

injury to the roots, result in less loss of moisture, and leave a larger proportion of the best top soil undisturbed for the use of the plant. Root injury is always less when the depth is regulated so that each cultivation is slightly more shallow than the preceding one. Cultivation after the plants become quite large may prove detrimental unless it actually is required to control weeds, which it will not be unless proper early cultivation has been neglected or prevented by wet weather. In fact, late deep cultivation, especially when close to the rows, results in severe injury to the roots and may reduce yields to a material extent. In considering the depth to cultivate it should be remembered that most vegetable crops develop extensive root systems with a large proportion of the feeding roots in the upper few inches of soil. Celery and onions, however, have relatively restricted root systems and the middles between rows of these crops may be cultivated quite thoroughly and deeply.

Level tillage and hilling.—Level or nearly level cultivation is standard practice. Hilling of suitable degree is the most economical way to kill weeds in the row, when they have gotten a real start during wet weather, and it is employed also for special purposes that are discussed in chapters on the individual crops.

Efficiency in cultivation.—Narrowing the uncultivated row-strip to a minimum is a most important factor in reducing expenditures for hand labor. Suitable attachments, appropriate adjustments, and watchful supervision will secure closer cultivation than most workmen think possible. In the first wheelhoeing of lettuce, beets, and other small crops an uncultivated strip of one or two inches provides sufficient leeway. In cultivating cabbage, tomatoes, potatoes, sweet corn, beans, and other coarse crops it is a great advantage to operate at fairly rapid speed so that a wide, shallow layer of soil may be thrown over the uncultivated strip to smother weeds. To effect this most advantageously the two shovels nearest the row that is being cultivated should be exactly opposite each other and working at precisely the same depth. Thus, the pushing effects of the two sheets of moving soil will equalize over the center of the row and very few plants will be upset or covered. As mentioned, timeliness is a most important factor in efficiency of cultivation. Very little delay may increase the cost of hand labor enormously.

Implements and tools used in cultivating.—There are three general classes of cultivators: horse cultivators, motor cultivators, and hand cultivators. In market gardens one-horse cultivators commonly are used wherever space permits tillage with horses. Such cultivators may be adjusted in a moment to work between rows of different widths or plants of various sizes or characteristics, and are always under the quick control of the operator. In larger opera-

tions the sulky or riding two-horse cultivators that work both sides of one or more rows at a passage provide efficient and economical tillage.

Motor cultivators are of two general classes: those mounted on general purpose or row-crop tractors to cultivate one, two, or more rows as the case may be; and the small garden tractors which cultivate one to three rows as permitted by the crop, spacing, and soil. On soils that are not too hilly, motor cultivators prove very efficient and economical and provide the important advantage of operating long hours in emergencies. They are used exclusively on many highly mechanized farms.

S. L. Allen & Co., Inc.

FIG. 49.—Two-horse riding cultivators for working one or more rows are efficient and economical, the best for a great many conditions.

Wheel hoes are the standard hand-cultivators in close-rowed market garden crops and are nearly indispensable in the home garden. Double-wheel hoes are most serviceable in smooth, level soil that is easily cultivated; the single wheel hoe is adapted to conditions not so favorable to tillage and for working between the rows. Teeth, knives, sweeps, and shovels for wheel hoes are available in varieties to meet all conditions. The knives are especially valuable for use in sandy soils. They may be shortened to cultivate rows

only 6 inches apart, although 10 to 14 inches are usually allowed for wheel hoe cultivation.

Ordinary garden hoes, special hoes of many kinds, rakes, and hand weeders are employed for stirring the soil and removing weeds between the plants in the rows, as well as for cultivating the entire area of garden when more effective equipment is not available.

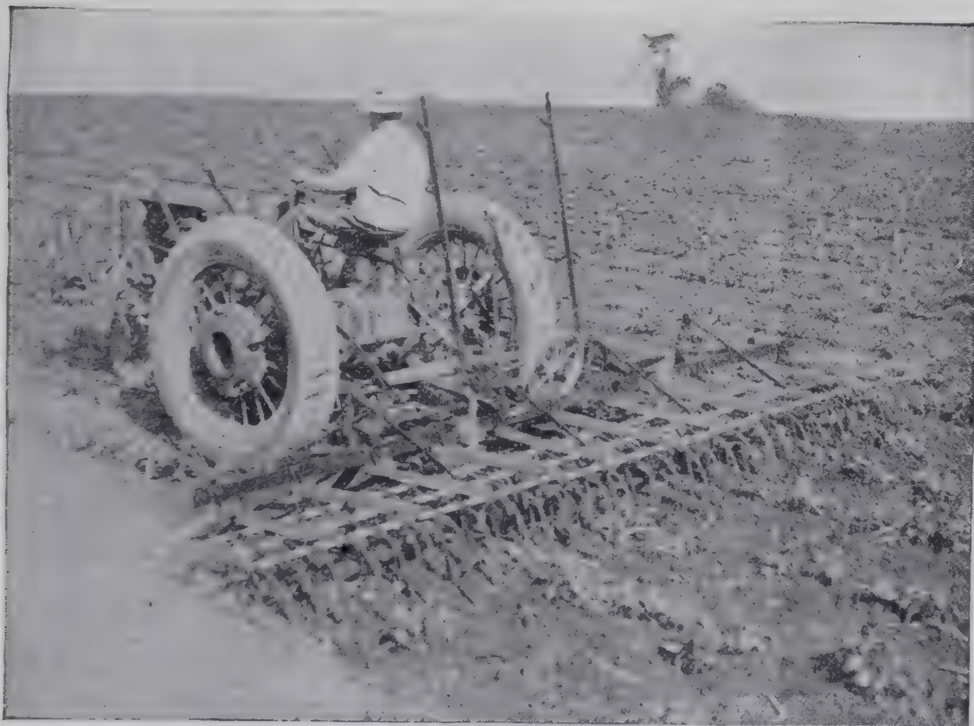
International Harvester Co., Inc.

FIG. 50.—The capacity to work long hours and complete the cultivation in time are often the greatest advantages of motor equipment.

Discussion of implements used for cultivating would not be complete without mentioning the springtooth harrow which is commonly used to stir the soil after planting potatoes or other deeply-placed seed. The spiketooth harrow is often used for the same purpose and also to break crusts and kill small weeds even after potato or corn plants begin to appear above ground. Horse or motor-powered weeders, with long flexible teeth, may be used in the crops mentioned until the plants are a foot high, and to a limited extent in some other crops, such as peas or beans. Rotary hoes are somewhat similar in application and effect. Such implements are remarkably effective, when operated at frequent intervals, in destroying small weeds in the rows. Damage to foliage is surprisingly small when they are used during the heat of the day. Bruner weeders are wheel-hoe size machines which operate on the same principle. They and large spring-toothed rake-like weeders are very satisfactory on smooth, friable soils in removing tiny weeds, for ex-

ample, from onion rows. Weeders of the type described must be used frequently for best results.

It is a serious error of management to fail in providing enough cultivating equipment of types well adapted to the conditions. A small saving in implements may cause great loss in higher cost of weeding or reduced yield.



International Harvester Co., Inc.

FIG. 51.—The weeder, operated by either tractor or horses, is indispensable for low cost weed control in potatoes and corn and sometimes is used in peas, beans, or other crops.

Cultivator attachments.—To be able to cope effectively with different cultivating problems it is an advantage to have several styles or sizes of cultivator attachments. Shovels two or three inches in width are used most generally and are effective in destroying weeds of ordinary size and in penetrating hard soils. Wider shovels may be more suitable when very large weeds must be subdued. Very narrow shovels, peg-teeth, and knife-like attachments are most useful in light, easily-worked soils. Sweeps of various styles are suitable in many cases and often are employed to cut off large weeds without disturbing the soil to great depth. Discs, hillers, and shovels of many sizes and forms are available for special purposes. Careful selection and adjustment of the attachments to the work at hand may be the means of greatly increasing the efficiency of cultivation.

Hoeing and weeding.—It has been indicated that expenditures for labor may be reduced materially by managing cultivation to eliminate as far as possible the tedious, time-consuming operations of hoeing and weeding. Skilful growers sometimes manage to keep the land clean by frequent and thorough cultivation alone, but at least some hand work is nearly always necessary, especially with the smaller growing, more closely spaced crops. If attended to when the first tiny weeds appear, hoeing and weeding proceed rapidly and effectively. The cost is likely to be multiplied many times if the work is neglected until the weeds are well started, and by that time they may have injured seriously the prospects for the crop. Weeding and thinning are usually carried on as one operation, for example with beets, carrots, lettuce, or the cucurbits.

John Deere

FIG. 52.—Many crops will not pay for expensive hand weeding. Weed control should be accomplished mainly with the cultivator. Special equipment may be needed for high efficiency in certain operations.

Thinning is an important operation in growing many vegetable crops. It is a process of reducing the numbers of plants and of selection; the weakest plants should be discarded and the most vigorous left to mature. Liberal sowing and subsequent thinning practically assure a perfect stand which is a necessity for the maximum yield. The operation, however, is very tedious and expensive, and sufficient labor often is not available. It is good management to avoid thinning as much as possible by means of good seed beds, germination testing, and correct distribution and covering of seed. But thinning is a necessity with lettuce, for example, and its neg-

lect is a serious matter. To avoid disturbance of the remaining plants, thinning should not be delayed until the seedlings, or weeds, become large. Specific recommendations for thinning are included with discussions of the several crops.

Mulching to control weeds is practiced to a limited extent. Special mulching paper, asphalt-treated paper, or any other durable paper that does not contain soluble, injurious materials may be used but they are too expensive for most purposes. Seeds are sown or plants are set through slits cut in the paper or in narrow spaces between strips of paper. Numerous staples, stones, or other weights must be used to hold the paper in place. In addition to controlling most of the weeds, mulching with paper conserves moisture and, under some conditions, raises the soil temperature. In a number of instances somewhat earlier and larger crops of the warm-season vegetables have been secured with mulch paper and the advantage of producing cleaner vegetables is considerable. The expense of the practice, however, limits it to special purposes.

Heavy mulching with straw, leaves, or other litter also controls weeds effectively, conserves moisture, and keeps tomatoes, for example, clean and attractive. It should be noted, however, that vegetables mulched with straw may not yield so heavily under some conditions as those receiving normal cultivation, and often grow yellowish unless additional nitrogen is applied (p. 75).

Special practices for weed control.—The larger growing vegetables, especially on bottom land where weeds are a great problem, often are planted in check rows so that cultivation may be both with and across the rows. Thus hand-hoeing is eliminated or reduced greatly. Check rowing, however, is not generally employed in most sections. The operation of planting is more exacting and lower yields often are secured with sweet corn, for example, when the plants are grouped in hills rather than distributed evenly in rows.

Composting manure to kill weed seeds before application to the land has been mentioned (p. 78).

The use of chemicals to kill weeds is rarely applicable to the conditions of vegetable gardening. The use of cyanamid as a fertilizer and to kill weeds, however, may be practicable under some circumstances, particularly in the culture of asparagus.

A common practice in intensive gardening is to carry off and compost or otherwise destroy weeds that have been pulled or hoed. The purpose is to prevent the weeds from catching onto the soil in the event of showers or irrigation, and to get them out of the way of cultivation. An additional purpose that deserves more general consideration is to prevent the shedding of seeds that may ripen after the weeds have been uprooted. Purslane contains enough water

when cut in full bloom to bring many seeds to maturity, and numerous other weeds have the vtiality to ripen extremely immature seeds. The additional cost of preventing production of weed seeds in one year may be more than recovered in later reduction of the expense for weeding.

IX

IRRIGATION

ALTHOUGH irrigation has been employed extensively in arid and semi-arid regions for thousands of years, it is only within the present century that the practice has become important in humid regions. Many early market gardeners in this country recognized the need for artificial watering. As a general rule, however, they found the surface methods of irrigation that are common in the West poorly adapted to the uneven contours and easily puddled soils usually found in the East. A few growers irrigated by furrows or by flooding with large hose and, to a limited extent, with lawn sprays oi the sprinkler types. Even the latter method was not generally satisfactory because the water was applied rather unevenly, the rate of application was too rapid for any but the coarsest soils, and the expense of installation was great.

The Skinner Irrigation Co.

FIG. 53.—Irrigation is considered almost a necessity among market gardeners and is employed by some extensive growers.

Irrigation of vegetable crops in the East did not become common until after the perfection of the variously called, overhead sprinkler, spray, or Skinner system of irrigation. In the summer of 1896 C. W. Skinner built and operated the first overhead irrigation line as it is used today. After making various refinements he began to

introduce the system in 1904. Studies made by the New Jersey Agricultural Experiment Station indicate that very few irrigation systems were in use in that state prior to 1910, but that general appreciation and widespread installation began that year. Today many thousands of acres of high-value vegetable crops are grown with the aid of sprinkling irrigation.

Functions of water in the life of plants.—Consideration of the subject of irrigation should proceed with appreciation of the more important functions of water in the life of plants. In the soil, water serves as a solvent of nutrients, and is aided in this capacity by organic acids which it holds in solution. It also serves as the vehicle in distributing nutrients to the roots of plants and is essential for the activities of soil organisms. In the plant, water serves as a medium of conveyance of raw nutrients and elaborated foods. It also functions as a nutrient. Several hundred pounds of water are transpired to make a pound of solid plant tissue. Water makes up more than 90 per cent of the weight of nearly all vegetables.

Need of irrigation.—By observation of the effects of rainfall and irrigation, or of their lack, growers have come to agree that approximately an inch of rainfall or its equivalent—that is, 27,154 gallons or about 110 tons of water to the acre—is required every week or ten days in humid regions to maintain uninterrupted growth of most vegetables during normal summer weather and on average soils. With some crops under conditions of rapid evaporation the requirement may be as great as an inch of water every 4 or 5 days.

Nearly all the important vegetable gardening districts of the East are located within the range of 40 to 50 inches of average annual precipitation. Satisfactorily even distribution of rainfall, however, is more often the exception than the rule. Both the statistics of weather and the experience of gardeners indicate that few growing seasons pass without at least one period of three or more weeks in which rainfall is very inadequate for crops that are sensitive to drought. Even in seasons of good rainfall, irrigation is extremely useful in starting seeds or transplants on scheduled time. Growers who have had irrigation equipment for many years report that they use it to advantage to a small extent in every season.

Benefits of irrigation.—Irrigation is an insurance against loss through inadequate rainfall, which is one of the greatest risks confronting the gardener. But irrigation is much more than that. In many localities, and at certain seasons, celery, lettuce, onions, cauliflower, or other drought-sensitive crops may be grown successfully only with irrigation; their culture without its aid would be futile in most years. With irrigation, successive plantings of quickly-growing crops, such as radish and spinach, will germinate promptly to provide continuous supplies for market, and transplanting may pro-

ceed at the appointed times regardless of drought. Irrigation often is the means of securing earlier maturity, more attractive appearance, higher quality, and very remarkable increases in yield. Lack of water, more often than any other cause, is the limiting factor in the attainment of maximum potential yields as determined by the productivity of the soil and the breeding of the seed.

Hamilton Mfg. Co.

FIG. 54.—Sprinkler irrigation line, portably mounted on wheels, a method most common in Michigan celery fields.

It is stated sometimes that equal crops can be grown with less manure and fertilizers when irrigation is practiced. To a degree this is true, but irrigation is an expensive undertaking that should not be limited in effectiveness by inadequacies in other respects. There is no doubt, however, that the attainment of full benefit from moderate fertilization with irrigation may be more conspicuous than the partial benefit often secured in dry seasons from heavy fertilization without irrigation.

Methods of irrigation.—There are three general methods of irrigation; (1) sub-irrigation, (2) surface irrigation, and (3) overhead or sprinkler irrigation. The first two are of special advantage under some conditions. The last is the only method which is generally adapted to conditions on the majority of vegetable farms in the East, and it will be discussed in more detail.

Sub-irrigation.—Theoretically this is a very desirable method of watering. Parallel lines of ordinary farm drain tile are laid in the soil at a convenient depth, with a minimum grade of 1 inch in

100 feet, and at intervals of 10 to 25 feet, depending on conditions. The lower ends of the lines are connected to ditches or tile drains to provide drainage when the soil is too wet. In irrigating, the lower ends of the lines are plugged and water is admitted at the higher ends until a sufficient amount has been applied. Because the water seeps from below, evaporation is reduced, baking of the soil and wetting of the foliage are avoided, and there is little interference with tillage. On the other hand, considerable outlay is required for tile and, in most soils, percolation is too rapid and lateral distribution of the water is slow and confined to a narrow range.

The essential conditions for successful sub-irrigation are found extensively at Sanford, Florida. They consist of: an impervious subsoil a few feet below the surface to prevent the downward escape of much water, a layer of gravel or coarse sand, to assure rapid absorption and distribution of the water, and in which the tile are laid, topsoil of high capillarity, and level land. Sub-irrigation is the least used of the three general methods because suitable conditions are rare.

Surface irrigation is in general use in the West and is used in the East to a limited extent. A few favorably situated Eastern growers use the furrow system of surface irrigation extensively. It is necessary that the land be comparatively level, or that it be

Bureau of Agricultural Engineering, U. S. Department of Agriculture

FIG. 55.—Furrow irrigation may be useful in emergencies even in humid regions; on a few favorable areas it may be the best method. The slope must not be excessive.

graded, which is impossible in the usually shallow soils of humid regions. By mapping the contours and planting along them, however, furrow irrigation is possible on slightly sloping land. The furrow system, it should be noted, is the most generally useful form of surface irrigation. The water is merely run into shallow furrows between the rows, or between narrow beds or ridges. A fall of between four inches and a foot in 100 feet of furrow is about right in most soils, to carry the water quickly to the distant end without excessive erosion. A sufficient volume of water should be admitted at first to fill the entire furrow rather quickly, so that both ends of the rows of crops will secure approximately equal irrigation. As the rate of absorption slackens, less water is admitted and part of the flow is diverted to the next furrow. The continuous service of an attendant is required to control and direct the flow. However, the expense of making the furrows is small, very little equipment is required, and it is necessary only to pump this water to the level of the highest point to be irrigated, not to establish a pressure at the field. Objectionable features are that more water is required than with the sprinkling system, percolation may be excessive in very porous soils, and the areas occupied by the furrows may bake in very heavy soils. Furrow irrigation is not well adapted to either very porous or very impervious soils.

Flooding is a form of surface irrigation in which water is run over the entire area, which must be in very level plats. Borders or slight ridges of soil sometimes are raised to retain the flow of water in rectangles of convenient size and elevation. Flooding is used sometimes with great success as an emergency method of irrigation for the larger-growing crops. In such cases the water may be conveyed to suitable points by means of large hose. Uniform distribution is difficult, however, the water is applied too rapidly for most soil types, and heavy soils tend to bake and become too compact where flooding is employed in watering cultivated crops. There are many variations of this method.

Porous canvas hose may be considered as a specialized form of surface irrigation. The procedure is to unroll a length of porous canvas hose between two rows of plants and to irrigate by the seepage of water pumped into the line at low pressure—10 pounds is sufficient. A variation is to use hose having small eyelets every two feet. When enough water has been applied in one position, the hose is moved between the next pair of rows, and a concave pulley mounted on a convenient handle will prove most helpful in this operation.

Some packing or puddling of the soil may occur, more water seeps out at the low places, and the system is not ideally adapted for watering small seeds. The water is applied quite evenly, how-

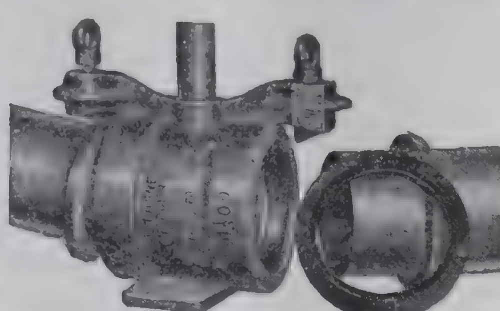
ever, with little waste or loss from evaporation, and low pressures do not call for expensive pumps or large consumption of power. But it should be considered that the cost of a given length of canvas hose is not materially less than an equal length of sprinkling irrigation line and that the useful life of the hose is much shorter. The labor requirement is rather high.

Suitable hose may be purchased or manufactured at home with the assistance of a sewing machine similar to that used by harness-makers or shoemakers. Tubing about 2½ inches in diameter may be made from canvas cut into strips 9 inches wide. Eight-ounce material is suitable for short lines. Lines as long as 600 feet or more may be made by providing about 200 feet of 8-ounce canvas at the outer end, 10-ounce material next for lengths up to 400 feet, and 12-ounce weight on the end toward the pump for longer runs. Connections may be made to the supply pipe and between lengths by providing sleeves of pipe or sheet metal, to slip inside the hose, which are secured by clamps similar to those used on garden hose.

OVERHEAD IRRIGATION

Recently the rotary sprinkler system has come into new favor with the development of efficient non-stalling wide-radius sprinkler heads which are used, as a rule, with portable lines of light-weight galvanized steel pipe connected by quick acting couplers as illustrated. The lines are easy to move and sufficiently flexible for uneven land. Easy portability is an important advantage under many

Buckner Mfg. Co.



Derbyshire, Mack and Morgan, Inc.

Fig. 56.—Two popular types of quick action couplings used in joining and disjoining portable lines. Sprinklers are mounted on long nipples screwed into the couplings.

conditions. The overhead pipe system of sprinkling irrigation, however, is the system most extensively employed by eastern vegetable gardeners.

Advantages of overhead irrigation by the system first developed by Skinner may be summarized as follows: (1) The water

falls in a fine spray, thus preventing packing, crusting, and erosion of soil as well as bruising of foliage. (2) Even watering is assured by uniform distribution at a rate which does not exceed the absorptive capacity of the soil. (3) Hilly land and areas including various types of soil can be irrigated without difficulty. (4) Less water is required because the application is even and wastage is eliminated. (5) The labor of irrigating is small. (6) Wind erosion can be controlled, and, under some conditions, frost injury may be prevented, because the system can be put into operation over a large area at a moment's notice. In dry times aphids often are less troublesome on peas, cabbage, or other crops with overhead irrigation.

Costs and returns.—Although the benefits of irrigation are numerous and important, the expense is considerable. For what crops and under what conditions will irrigation prove a profitable investment? Cost of installation and operation for the individual farm should be estimated before attempting an answer.

Nozzle lines alone cost \$150 to \$200 per acre of coverage. To this must be added the cost of supports, which may be very little when low posts of second-hand material are used, or as much as \$100 an acre when substantial supports of permanent nature are included. Thus, the cost of field equipment may range from \$150 to \$300 to the acre of coverage with permanent installation.

If labor is available to move the nozzle lines from strip to strip as irrigation proceeds, however, the expenditure for field equipment may be reduced by increasing the number of strips to be watered by each line. When labor is expensive or limited in supply, it may be difficult to move each line more often than three times a week. But with cheap or abundant labor the nozzle lines can be moved daily to irrigate 6 times the area covered at one application. Thus the cost for the portable nozzle lines may be only \$25 to \$50 an acre to be watered, a third or a sixth as much as in permanent installations. The outlay for supports may be practically eliminated by placing the lines on the ground, or on crates, boxes, or short stakes when foliage interferes with the jets. As an emergency measure the lines may be moved each morning and evening if labor is available.

The costs of the pumping plant and supply lines vary greatly with the depth of the water supply and the elevation and distance to the field. Where the water supply is at or near the surface and close to the field the pumping plant may cost as little as \$75 to \$100 an acre to be irrigated at one time. To this must be added the cost of mains, fittings, valves, and risers, to convey water to the nozzle lines, and labor, which are likely to be at least \$25 an acre. For deep-well pumping or high lifts and for long distances to the field, costs would be much higher.

By totaling estimates it is apparent that portable irrigation, with

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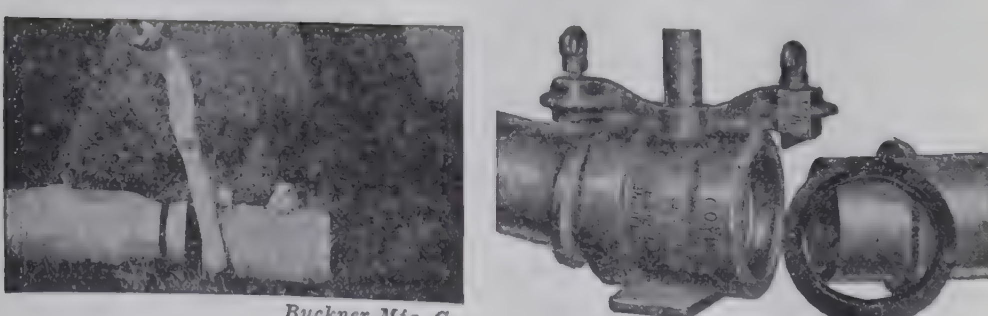

Buckner Mfg. Co. *Derbyshire, Mack and Morgan, Inc.*

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By totaling estimates it is apparent that portable irrigation, with

a sixth of the acreage covered at one time and a pumping plant of proportional capacity, may be installed for about $75 an acre under favorable circumstances. Permanent equipment under equally favorable conditions would cost about $250 an acre. Both of these estimates may be doubled where the pumping plant must be of a costly type or the distance to the field is great.

Figures on the actual costs of irrigation were secured by the New Jersey Agricultural Experiment Station in 1925 in a survey of 346 farms in that state, on each of which there was at least one acre of sprinkling irrigation. Of a total of 2658 acres under irrigation, 2021 acres were in permanent systems and 637 acres were in movable systems. Average costs of irrigation with permanent systems were: investment $415.30, operation $23.37, and repairs $4.40. Comparable figures for movable systems are: investment $124.41, operation $30.50, and repairs $5.96. The life of equipment was found to be about 20 years. If 10 per cent of the investment cost is used to represent interest and depreciation, and costs of operation and repair are added, a typical annual charge of $69.30 is secured for the permanent system and $48.90 for the portable system.

It is apparent that installation of irrigation can not be justified for crops of low value and that the place for irrigation is in intensive operations, where returns often may be increased at least $50 or $75 an acre by the use of water. The value of irrigation as insurance under such conditions also is very great, as the grower of high-cost crops without water at his command risks the loss of $200 or more to the acre in production costs in the event of prolonged drought.

Permanent or portable systems.—Some of the relative advantages of the two systems have been mentioned. Unquestionably

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FIG. 57.—Rotary sprinkler irrigation used with light weight portable pipe.

there is a place for both, often on the same farm. Investment in portable irrigation will protect several times as large an acreage and may be very desirable when capital is limited or if crops of the highest value to the acre are not to be grown. On the other hand, moving the nozzle lines every day in dry times is an annoyance, even though the actual outlay for labor may be less than the increased charges for interest and depreciation with permanent systems. For the most intensive operations nearly all growers prefer permanent equipment because only one man is required to care for the system at any time. On the contrary a material advantage with portable lines is that they may be carried out of the way, after the crops have been harvested, to permit unobstructed tillage in any direction. And, of course, portable lines can be mounted permanently at any time it may become desirable to do so.

Water supply.—The first consideration in planning for irrigation is to make sure of the source of water. Sometimes equipment has been installed with capacity in excess of the water supply. If there is doubt concerning the adequacy of the supply the prospective irrigator should actually measure the flow of springs or small streams, either by diverting them into vessels of known capacity or by the use of weirs. The best method with wells is to make a 10-hour pumping test. A flow of about 50 gallons a minute is required to irrigate an acre at a time with the common overhead system and irrigation at this rate must continue for 9 hours to apply the equivalent of an inch of rainfall—in fact a run of 10 hours or more may be required in hot, windy weather on account of the high rate of evaporation. By pumping night and day this flow would thoroughly irrigate about 15 acres a week, as long as dry weather might continue. To operate a single line 210 feet long would require only one-fourth as great a flow, or 12½ gallons a minute. About 2 acres a week can be irrigated with one such portable line, if it is moved daily. On account of the tremendous amounts of water that are required—nearly 30,000 gallons to the acre-inch of irrigation—it is usually cheaper to pump directly into the supply mains than to use storage reservoirs, even when they can be located at sufficient elevation to provide the necessary pressure by gravity. Storage basins are occasionally necessary, however, to accumulate small flows into volumes that can be used for irrigation.

Pumping plant.—As stated in the preceding paragraph, 50 gallons of water a minute will be required to irrigate an acre at a time, and it is better to figure on a slightly higher capacity, perhaps 60 gallons a minute, to make up inefficiencies or to provide full pressure as the nozzles become worn. Pumping capacity for larger or smaller areas may be figured on that basis. A working pressure of 30 to 45 pounds to the square inch at the nozzle lines is ideal.

Higher pressures are neither necessary nor desirable as the jets tend to break into mist and fail to reach their normal distance, and more power is required. Pressures below 25 pounds are not desirable, although lines have been operated with only 15 pounds of working pressure. The pressure at the pump must be enough greater to overcome the frictional losses of pressure en route and the elevation or lift to the field, the latter being 0.433 pounds to the square inch for 1 foot head of water, or about 22 pounds for 50 feet of elevation.

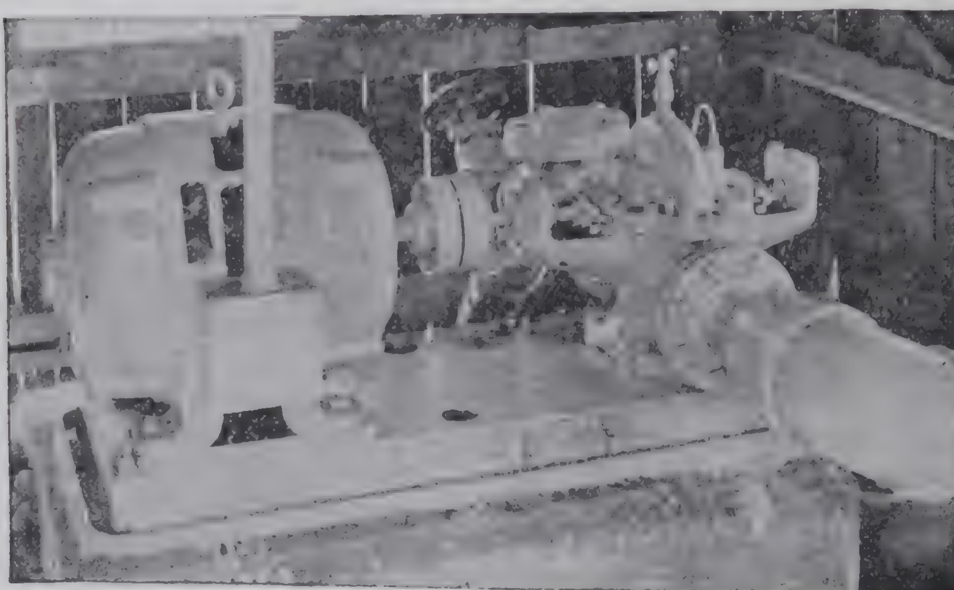


FIG. 58.—Centrifugal pumps are economical and very efficient for most irrigation requirements.

Piston pumps, commonly used for the smaller and medium-sized installations, are especially suitable for operation with ordinary low-speed gasoline engines. Rotary pumps are not generally popular for irrigation. Centrifugal pumps are very satisfactory and efficient, when they are designed for the particular conditions of operation and are installed properly. They are used very generally for pumping large volumes and may be secured to operate successfully at pressures of 100 pounds or more when the conditions are specified to the makers. Centrifugal pumps directly connected to electric motors or internal combustion engines are one of the most economical and satisfactory purchases.

Relief valves of suitable capacity must be installed in connection with piston pumps but are not required with the centrifugal types, in which the confined water merely rotates with the impeller when

all outlets are closed. This is a matter of great convenience when closing and opening valves in the field to direct water to different areas. If all valves are closed for some time and there is no leakage, however, the water in high-speed centrifugal pumps may become dangerously hot.

Where the water is at a considerable depth some form of deep well pump usually is required which is certain to be more expensive than the ordinary piston and centrifugal pumps. It may be possible to dig a pit when the water level is not excessively deep, however, and to install an ordinary type of pump within the maximum practical suction lift, which usually is considered to be 20 feet.

It should be noted in installing pumps that efficiency is greatest when the pump is no higher than necessary above the water level. Use of too small pipe on the suction line will increase friction and have the effect of increasing the suction lift. A very small leak in the suction pipe will admit a great amount of air. Such a condition will greatly reduce the efficiency of any pump and may make it difficult or impossible to operate a centrifugal pump.

Supply lines or mains.—Because it costs more to pump water under high pressures, the supply lines should be large enough to deliver the water to the nozzle lines with small loss in pressure, preferably not over 10 or 20 pounds for average pumping conditions. The rate of flow, size of pipe, and length of travel determine the frictional loss of pressure. A supply line to water a half acre at a time may be constructed of 1½-inch pipe, if the distance to the field is not over 200 feet, and of 2-inch pipe for distances up to 600 feet. To water an acre at a time 1½-inch pipe will be satisfactory for distances less than 100 feet, but 2-inch pipe is better and will suffice up to 400 feet, although 2½-inch pipe should be used throughout for much longer lines. A single nozzle line 100 feet long may be supplied by a 1-inch pipe at distances not exceeding 200 feet, 1¼-inch pipe should be used if the length is greater, but not over 400 feet, and for longer runs 1½-inch pipe will be required.

Pipe sizes for other distances or larger flows can be calculated by referring to the tables on page 154 (from Bul. 453, New Jersey Agricultural Experiment Station).

Unless the grower has had training or experience in irrigation, money probably will be saved and more satisfactory operation assured by having a competent engineer assist in the design of extensive installations. The manufacturers of nozzles and fittings are ready to assist in such matters. It is important to provide the desired flow and working pressure at every riser, without the use of too high pressures or unnecessarily large pipe. Standard weight black steel pipe is usually most economical for the main underground supply lines. It lasts 20 years or more in most soils and may be re-

placed by the saving in cost and interest over cast or wrought iron pipe. Galvanized pipe is used for the risers which extend above ground at intervals of 50 feet along the headland, or through the middle of the field if nozzle lines are to extend in both directions.

SUGGESTED SIZE OF PIPE FOR MAIN FEED LINE

This assumes uniform size from pump to first riser with a pressure loss not much over 5 pounds per square inch.

Water	Length of Pipe in Feet							
	50	100	200	300	400	500	600	700
gallons per min.	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
10	1	1	1	1¼	1¼	1½	1½	1½
20	1¼	1¼	1¼	1½	1½	2	2	2
30	1¼	1½	1½	2	2	2	2	2½
40	1½	1½	2	2	2	2½	2½	2½
50	1½	1½	2	2	2	2½	2½	2½
60	2	2	2½	2½	2½	3	3	3
100	2½	2½	3	3	3	3½	3½	3½
200	3	3½	3½	4	4	4	4	4
300	3½	3½	4	4	4	4	5	5
400	4	4	4	5	5	5	5	6
500	4	5	5	5	6	6	6	6

FRICTION IN PIPES

Pressure lost per 100 feet of pipe

Flow	Size of pipe in inches, inside diameter									
	¾	1	1¼	1½	2	2½	3	3½	4	5	6
gallons per min.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
10	16.45	5.06	2.89	0.62	0.22						
20			4.80	2.23	0.78	0.26	0.10				
30			10.16	4.75	1.66	0.56	0.23				
40				8.13	2.85	0.95	0.39				
50					4.29	1.43	0.60	0.17	0.15		
60					6.02	2.01	0.85	0.26	0.20		
100						5.51	2.15	0.38	0.53	0.18	
200							7.70	0.96	1.91	0.64	0.24
300								3.33	4.03	1.36	0.55
400								7.70	6.91	2.34	0.91
500									10.40	3.51	1.37

Nozzle lines.—Pipe for nozzle lines may be bought ready to receive the nozzles or it may be drilled and tapped by the grower with the use of inexpensive drilling machines designed for the purpose. It is most convenient to assemble the pipe on the ground where it is to be used, or on an adjoining driveway, screwing the joints tightly together to prevent unscrewing when the lines are

rotated to direct the spray. For convenience in drilling, the assembled line may be placed on the posts which are to support it or on trestles, boxes, or barrels. Untimely rotation during the process of drilling is prevented by screwing a tee on the larger end of the line, with a full length of pipe extending at right angles and with one end on the ground. With careful workmanship it is not difficult to secure good alignment of the nozzles and the grower usually saves by purchasing the necessary tools to construct the system with his own labor.

Standard weight galvanized steel pipe will last 25 years or longer in nozzle lines and as a rule is preferred to the more expensive and enduring but easily bent wrought iron pipe. Pipe sizes are graduated to accommodate the flow necessary to operate the desired length of line. With standard nozzles spaced 3 feet apart the maximum permissible lengths of each size of pipe are approximately as follows, beginning with the outer end of the nozzle line: 80 feet of ¾ inch, 100 feet of 1 inch, 120 feet of 1¼ inch, 120 of 1½ inch, and 180 feet of 2 inch. Many growers build the outer 180 feet entirely of 1-inch pipe because it is stiffer and stands handling better, and the cost is very little more than when ¾-inch pipe is used. Two-inch pipe is not used to a great extent in nozzle lines because it is both expensive and heavy. Lines up to 450 feet are commonly built without exceeding the 1½-inch size of pipe. In assembling nozzle lines it is customary to use full lengths and not to cut to exact amounts of each size.

Fittings for nozzle lines regularly include an automatic flush valve or inexpensive ¾-inch valve at the outer end to drain away sediment or scale, standard pipe sleeves between lengths of pipe, reducing sleeves—not bushings—to increase pipe sizes, and a turning union with a strainer at the end to connect with the riser. With very clean water the strainer may be omitted without causing difficulty, from clogging of nozzles.

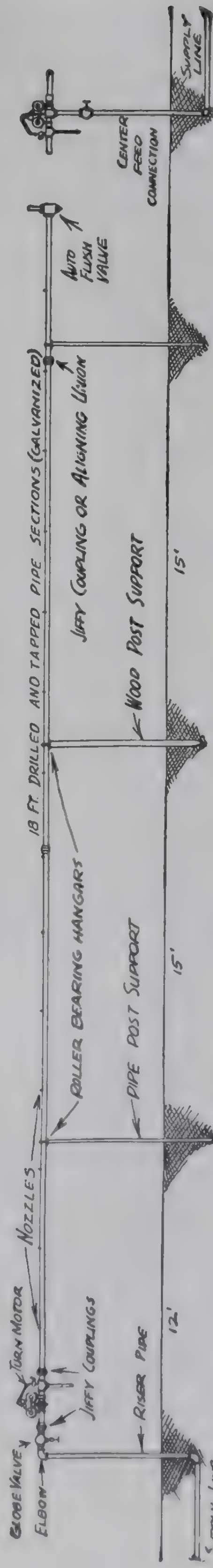


FIG. 59.—Installation diagram of overhead sprinkler system.

March Automatic Irrigation Co.

In assembling nozzle lines for portable irrigation it may be nec sary to install one or more special quick-acting couplings to disc nect the lines into lengths that can be handled by the number men available. If more than 20 or at the most 25 feet of pipe allotted to each man, breakage at couplings, or bending, will foll It costs less to carry the whole line without intermediate uncoupl when sufficient help is available. For portable lines it is a gr advantage also to omit the turning union and substitute an eight ten-foot length of good grade water hose of the same size as the p A handle for turning and the standard cone type strainer may installed in an ordinary tee. The flexibility of the hose, when l in a loop between the nozzle line and the riser, permits easy turn of the line to water on both sides. A more important advant of the hose is that the portable nozzle line may be set down w the end anywhere within a few feet of the riser and one man make the connection in a moment. In connecting without a h more time may be consumed in maneuvering the line to the corr angle, elevation, and longitudinal position for starting the thr than is spent in carrying it from one riser to the next.

Supports for nozzle lines.—Supports for portable lines ra from the ground itself, when foliage does not interfere with the j to boxes, crates, and temporary or permanent stakes. Someti wheels are used as shown in Fig. 54. Lines as long as 450 feet the ground may be turned without difficulty by hand. Perman nozzle lines often are supported by very inexpensive low posts most growers prefer to have about 6½ or 7 feet of head room cross harrowing and for convenience in working among the plan Plain wooden posts are commonly used, with a pair of large nails the top to keep the line in position. Posts of second-hand pipe old boiler tubes are very inexpensive and satisfactory. Spac should be 12 or 15 feet apart, not over 15 feet in the line and feet between lines. Special rustproof rollers are generally used carry the line on pipe posts and often on wood posts. By a ca system of suspension the number of posts may be reduced, wh results in less interference with cultivation but generally increa the expense of installation.

When to irrigate.—At the beginning of dry weather it is oft a puzzling matter to decide how soon to start irrigating. The de sion is not likely to be difficult when careful observation of t condition of the plants is supplemented with investigation of t moisture reserves of the soil by digging or by the use of a lar auger. Frequency of irrigation may be regulated by experien under similar conditions and by close observation of the respon secured.

Concerning the time of day to irrigate, it is customary to operate ight and day when necessary to cover the acreage. The investment n the irrigation plant is large and profits will be increased by using t to capacity in time of need. In the experience of many growers he danger of sunscald or tipburn from watering during bright days s not sufficiently important to be considered with most crops. However, it is safer to water lettuce and endive late in the afternoon or n the evening.

How much to irrigate.—Ordinarily the application of an inch of water every 5 to 10 days is sufficient to maintain steady growth. f, however, serious deficiency of moisture develops to a considerable lepth it may be advisable to apply two inches or more of water on vell established cabbage, celery, potatoes, or other large users of vater. To reduce the need for frequent shifting of portable lines t is desirable to apply at one irrigation as much water as the nature of the crop and the soil will permit. On the contrary, light daily watering may be required to start small seeds or delicate transplants n drying weather. Excessive irrigation is both harmful and unnecessarily expensive. Nitrification and other desirable soil processes are retarded by too much as well as too little moisture.

Turning the lines.—It is very important to manage the turning of lines so that the water is applied evenly on both sides. If the prevailing wind is from the northwest, hours of calm should be utilized in applying the water in that direction lest the wind arise and prevent that side from receiving its full share. On calm days or nights frequent rotation will be required to prevent puddles from forming on heavy soils or unequal distribution on sandy soils. An nch of water applied very evenly is likely to be more effective than an inch and a half poorly distributed. If a number of nozzle lines are in operation, one worker may be assigned with advantage to the specific duty of rotating them systematically and at frequent intervals; one hour is too long an interval when no air is moving. The expenditure for wages will be recovered several fold by the better results secured with less water.

Automatic, hydraulically-operated oscillators will rotate well-mounted lines satisfactorily. They are considered indispensable by many irrigators.

Frost control by the operation of sprinkling irrigation has not been invariably successful but, in many cases, crops have been saved. It is important to begin before freezing commences, to rotate the lines very frequently—every few minutes—and to continue watering for some time after the temperature rises above the danger point.

Preparing the system for winter.—Serious damage from freezing is not uncommon as a result of neglect or oversight in designing

the irrigation plant. In most parts of the North all supply pipes should drain to one or more convenient outlets which should be opened to draw off the water not later than November 1. Nozzle lines should be on supports that will keep them off the ground, and should be turned with the nozzles below and with the end valves or flush valves open. All valves on risers must be opened.

X

INSECTS AND DISEASES

Necessity of control.—With rare exceptions, the insects and diseases that affect vegetable crops can be controlled. Growers have no greater obligation than to be familiar with the most successful methods. Losses from the ravages of insects and diseases are universal; occasionally, entire crops are destroyed. It is even more significant, however, that only the exceptional grower, whether by fortune or management, escapes with losses as low as ten per cent, an amount which often exceeds net profit on the year's business. Apart from consideration of yield, it is necessary to control pests in order to produce attractive, blemish-free vegetables that will command the attention of buyers.

Obviously, the cost of control must not exceed the amount of the loss that is prevented, or the gain that is secured, and it should be much less. To be economical, control must be consistently effective at minimum cost. As a rule, consistent, effective, low-cost control can be achieved only by placing primary emphasis upon prevention. In most cases it is unsafe to depend mainly upon application of corrective measures after the onset of an attack. Success in the combat is dependent upon some understanding of the nature of the enemy and the manner of attack.

Insects and their attacks.—Insects that are injurious to crops may be classified into two groups: (1) The so-called chewing insects which actually devour portions of the plants. Their work is characterized by holes and missing areas in the plant tissue. Because surface portions are consumed, chewing insects may be killed by coating the plant with arsenicals, rotenone, or other stomach poisons. (2) The sucking insects which feed by extracting the plant juices. Their work usually is characterized by curling or twisting, and sometimes by graying, or even browning of the foliage. Because they can pierce a surface coating of stomach poison and feed beneath, sucking insects must be controlled by poisons which kill by contact or by the emanation of lethal fumes. Nicotine, pyrethrins, and rotenone are the more important active ingredients of "contact" insecticides.

It should be noted, in consideration of the importance of thoroughly controlling certain insects, that the unwelcome services of some of them in transmitting diseases over winter, and from infested to healthy plants, may result in greater losses than the direct effects of their feeding.

Vegetable diseases and their causes.—Diseases of vegetab crops may occur either as a result of the attacks of organisms, because of conditions unfavorable for growth. Identification of th cause, which is essential for appropriate control, often is easy, or may require the services of trained specialists, as in diagnosir chlorotic conditions that may be caused by virus diseases or b nutritional deficiencies.

Examples of diseases caused by organisms are: fungus diseas —anthracnose of bean, downy mildew of spinach, anthracnose cucurbits, Fusarium wilt of tomato; bacterial diseases—blight bean, wilt of sweet corn, canker of tomato; slime mould diseases- club-root of cruciferous crops; virus diseases—leaf-roll of potatoe mosaic and streak of tomatoes, and mosaics of bean, pepper an other vegetables; nematode diseases—root-knot of cucurbito crops, solanaceous crops, and many others.

Examples of diseases caused by unfavorable conditions fc growth are: nutritional diseases, as mentioned in Chapter VI physiological diseases, such as blossom-end rot of tomato when so moisture is inadequate, tip burn of lettuce when both temperatu and humidity are high, tip burn of potatoes in hot, dry periods, an sun-scalding of tomatoes; interior lesions and surface cracks whic are caused by unfavorable combinations of environmental factor

Life history and control.—Most insects and diseases live an propagate in definite cycles, including periods of dormancy and activity. Cheap and effective aids to control often may be secure by measures that are timed to kill the organism in a vulnerable stag of its life cycle, as in plowing under onion refuse not later than earl in May, that is, before the maggot fly emerges. Knowledge of th life cycle also may be the means of timing protective application just ahead of a general attack of an insect or a disease.

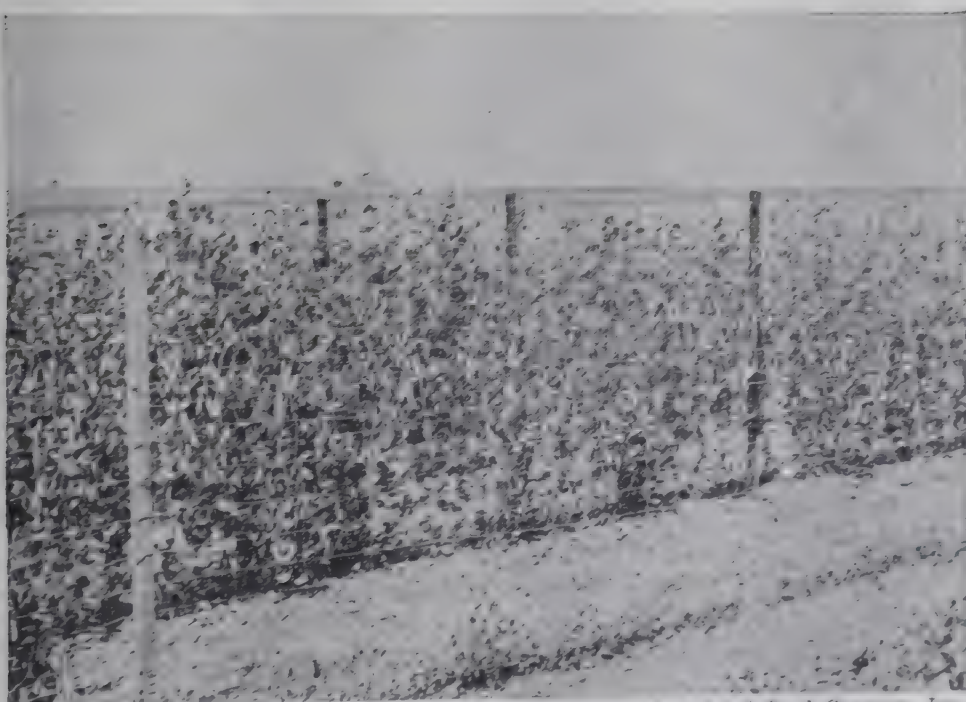
PREVENTIVE AND PROTECTIVE MEASURES

The importance of prevention is emphasized by the greate economy and certainty of success when the enemy is frustrate before the attack. It is impossible to combat many pests effectivel after they become established in the crop. Proper preventive mea sures often forestall losses.

1. **Planting clean seeds and plants.**—Insect-infested or diseas bearing seeds or plants are the most common and dangerou means of introducing pests into clean lands. Care should be take to produce or to procure the most disease-free seed or plants obtai able. Anthracnose of beans, pod-spot of peas, and many other see borne diseases are not readily controlled by seed treatments. Son others, such as black rot and black leg of the crucifers, canker, ba

terial spot, and early blight of tomato, may be controlled completely, or nearly so, by heat or chemical treatments of the seed. Descriptions of recommended treatments to combat seed-borne diseases will be found in Chapter III. Clean plants can be secured only by planting clean seed in clean soil and preventing recontamination. The plant buyer should investigate disease conditions and precautions taken on the premises of his plant grower.

2. Planting resistant varieties.—Remarkable progress has been made in the breeding of disease-resistant varieties. The planting of resistant varieties increases yields in many cases and, in extreme prevalence of certain diseases, it is the only means of securing a crop. Golden Cross Bantam and some other hybrids and crosses possess resistance to Stewart's wilt disease that permits their successful culture in localities where ordinary open-pollinated early and second-early yellow sweet corn fails. Many examples could be cited.



Associated Seed Growers, Inc.

Fig. 60.—Resistant varieties are a necessity under some conditions. Susceptible peas in the foreground have succumbed to wilt. Resistant varieties in the background are flourishing.

It should be noted that resistance is often in respect to only one specific disease. For example, Wisconsin Hollander and other yellows-resistant cabbages are not proof against club root. However, there may be unusual vigor or actual incidental resistance to other

troubles, as in the Marglobe and related tomatoes which are resistant to Fusarium wilt and also are less susceptible to various foliage diseases.

Resistance to insects is less common but not rare. Varieties of sweet corn which have tightly folded husks that extend well above the end of the ear are much less subject to injury from the corn ear worm. Aphis thrive to a greater extent on some varieties of certain vegetables than on others, or are more difficult to combat. The planting of resistant varieties when available is one of the most inexpensive and effective ways of control. Every grower should seek and test the new varieties that appear promising for his conditions.

3. **Rotation.**—Single cropping or the lack of proper rotation frequently causes trouble. When a crop pays unusually well, there is a temptation to continue its cultivation on the same ground, or to have it appear too often in the rotation. In either case insects and diseases affecting the crop are likely to multiply and accumulate to a dangerous extent. Crop rotation is one of the most effective and easily applied preventive measures in the control of insects and diseases (p. 180).

A more stringent application of the principle of crop rotation, one that may be useful as well as necessary in cases of severe and general infection, is to omit a certain crop or group of related crops for a suitable period of time. This may be the only means of eradication in some instances and is especially effective in eliminating club-root of the crucifers.

4. **Sanitation,** which deserves more general appreciation as a preventive measure, is applicable in three connections: First, the destruction of affected crop refuse often is necessary to prevent contamination of adjoining crops or lands. Burning is the most completely effective means of destruction and may be desirable in gardens where many kinds of vegetables are grown on a small area. However, burning of crop refuse destroys valuable organic material. In some cases it is needless and ineffective destruction of valuable material because a dangerous amount of inoculum inevitably remains. As a rule, it is sufficient to plow cleanly after the harvest and to level and compact the soil immediately.

A second step in sanitation is to eliminate harboring places in weeds or trash around the garden or field. Very often insect infestation begins at the edges of the planting. Flea beetles, borers, bugs, and worms of many kinds live and multiply in weedy borders.

A third very effective sanitary procedure is to destroy isolated plants, or groups of plants, that may become affected early in the life of the crop. Bacterial wilt of cucurbits, mosaic of tomatoes, or aphis of cabbage, for example, may appear first in a few centers from

which the attack may spread over the entire planting. Appropriate destruction of such sources on the spot or removal of the plants in tight containers will prevent or delay general dispersion.

5. **Timely plowing**, to bury affected refuse immediately after harvest, has been mentioned as a measure of sanitation. The plow should be adjusted to cover as deeply and cleanly as possible. Fall plowing long has been recognized as a useful means of combating cutworms, white grubs, wireworms, and various other insects that hibernate in the soil. Fall plowing should be timed before the insects have penetrated below plow depth, but not too early, lest they again burrow to a safe depth before winter arrives. Timely spring plowing may be required to prevent emergence of adult insects which have passed the winter as larvae, or to preclude maturity and dissemination of spores of many diseases. Crop refuse should be completely plowed under by early May in most parts of the north.

6. **Soil disinfection** (p. 44) is an important preventive measure that is employed generally in plant growing operations, but rarely in the garden or field, on account of the expense.

7. **Fumigation**, although more commonly used as a corrective measure, is very useful as a preventive. Strong concentrations may be employed in advance of planting to rid the greenhouse or plant structure of red spiders, white flies, aphis, and other pests (p. 487).

8. **Trap crops and baiting.**—Summer squash seeds may be sown earlier than the main planting of any cucurbit, or even at the same time. As the trap plants are not protected by repellents or insecticides, the insects congregate there and are killed in great numbers by spraying with kerosene. This procedure is quite effective against cucumber beetles, melon or pickle worms, and vine borers. In similar manner the population of Harlequin cabbage bugs may be reduced by trapping the insects on earlier plants of kale, mustard, or some other favorite cruciferous crop. In the late fall, specific insects may congregate on occasional squashes or other vegetables left in the field at harvest and can be killed.

Attracting insects by poisonous baits or by strong lights has been attempted but has not generally proved satisfactory.

9. **Mechanical protection** in the form of cones or domes of screen wire, cheesecloth, or transparent paper often is used to exclude insects from hills of cucurbits. Late cabbage plant beds may be screened with cheesecloth to prevent the maggot fly from depositing its eggs. Tar paper discs sometimes are used around the stems of early cabbage plants for the same purpose, and cardboard or stiff paper collars set partly above and partly below ground around the stems of plants will exclude cutworms.

10. **Chemical protection** includes both protective treatment of seeds and spraying and dusting. Protective treatment of seeds as with red oxide of copper, zinc oxide, or organic mercury dusts to protect the germinating seeds and young seedlings from damping-off organisms, is useful in the field as well as in plant growing. Spinach, peas, beets, early planted sweet corn, and some other seeds may be given protective treatment (p. 22).

John Bean Mfg. Co.

FIG. 61.—Complete coverage is being attained with high pressure and correct adjustment of nozzles. Truck mounted sprayers and dusters cover large acreages quickly and are convenient in reaching distant fields.

Spraying and dusting, in most cases, should be considered primarily as protective rather than as corrective measures. The ever-present possibility of unusually favorable weather for certain insects or diseases, such as prolonged rainy periods during which it is difficult to make effective applications, make protective spraying or dusting the standard practice in the production of celery and potatoes everywhere and of other crops in many places.

11. **Providing favorable environment** for the growth of a crop presents considerable possibilities in reducing or preventing the ravages of insects and diseases. Some crops may be grown so rapidly that they outpace the development of certain insects or attain marketable stage before the pests become particularly numerous or injurious. For example, very quickly grown radishes are likely to escape serious injury from maggots or aphis. Vigorously growing vegetables are retarded less by the attacks of insects, such as flea-beetles, and outgrow them more quickly.

Correct nutrition, as an environmental factor, assures well balanced growth that is less susceptible to attack by certain classes of disease organisms, and, in addition, avoids the development of mal-

nutrition or deficiency diseases, such as browning of cauliflower with insufficient boron.

Regulation of soil acidity is an important preventive measure that is commonly exemplified by the maintenance of a nearly alkaline soil to inhibit the development of club-root of crucifers and of a rather acid soil to check the scab organism of potatoes (p. 94).

Appropriate selection of planting times is an effective and practical means, under some conditions, of avoiding peak periods of activity of certain insects or favorable conditions for a specific disease.

Control of environment may include regulation of moisture by drainage or irrigation, and the increase of water-holding capacity by addition of organic matter. Ample, uniform supplies of moisture definitely prevent blossom-end rot of tomato and similar physiological troubles of some other vegetables, and reduce the amount of cracking of tomatoes, root crops, and celery.

CORRECTIVE MEASURES

In cases of mosaic, wilt, or other diseases that invade the interior of the plant, and of some insects, preventive measures are the only practical means of control. In others, as for example the pea aphis and the cabbage maggot and worms, corrective measures may or may not be required and the grower who watches daily for the onset of the attack usually may withhold treatment safely until he observes indications of the enemy. In a third group, including blights of celery and potatoes, both preventive and protective influences are instituted as a matter of routine by well informed growers.

The principal corrective treatments which may be undertaken after the crop has been attacked are: (1) fumigation, which is most useful under glass; (2) drenching the soil with suitable materials, as in the control of damping-off and root maggots; and, (3) application of insecticides and fungicides by spraying and dusting. In a few instances hand or mechanical removal of insects is possible. Application of fertilizers or of water constitutes specific treatment of some nutritional and physiological diseases and may provide helpful stimulation of growth in overcoming attacks of several diseases and of insects.

Spraying and dusting are the most important and generally applicable means of overcoming the presence of insects and diseases. To emphasize a point already made, applications of insecticides and fungicides usually should be instituted in time to serve in a preventive or protective capacity as well.

The guiding principle, in most cases, is to coat the plant with a film of completely enveloping protective armor which diseases and

chewing insects will be unable to penetrate successfully. In the case of sucking insects the control is likely to be satisfactory only when the material reaches and actually contacts at least 95 per cent of the pests, although strong fumes from nicotine dusts, under favorable conditions, will kill insects in close proximity to the application. When feeding is localized, as by the Mexican bean beetle principally on the lower surfaces of the leaves, the insecticide should be directed toward the affected areas.

INSECTICIDES

Nicotine, a contact insecticide, is widely used in combating sucking insects, of which aphids are the most generally troublesome example. It also is fairly effective when contacting certain chewing insects which may be present, such as worms on cabbage. Nicotine is comparatively ineffective when used alone in water, but is efficient in bordeaux mixture; the greatest efficiency, however, is secured when an activating and spreading agent is included, as in the formula, one pint nicotine sulphate and 3 to 5 pounds of potash fish oil soap to 100 gallons of water. The effect of the soap is to liberate nicotine and improve the wetting and spreading qualities of the spray. Ordinary cheap laundry soaps may be used but cannot be conveniently dissolved in cold water. If the freshly applied spray draws together into droplets the amount of soap is insufficient.

Nicotine dusts can be purchased ready mixed or they may be prepared by the grower. Concentrations of 2, 3, and 4 per cent nicotine are most commonly used, the higher percentages when infestations are serious, when the insects are resistant, or when conditions and equipment are unfavorable for efficient application.

To make a 2 per cent nicotine dust, place 95 pounds of hydrated lime or extremely finely pulverized limestone in a barrel mixer; add 5 pounds of nicotine sulphate (40 per cent) and a peck or more of small, smooth stones or large pebbles, rotate slowly for at least 5 minutes and then empty through a screen to remove the stones. If the preparation is not to be used at once, it should be stored in airtight containers, preferably in a cool place. To make 3 and 4 per cent nicotine dusts use 7½ and 10 pounds, respectively, of nicotine sulphate (40 per cent) and enough of the diluent material to make 100 pounds of mixture. Dust mixers are shown in Figures 6 and 7.

When a dust mixture is desired that will contain also a stomach poison, the amount of lime in the foregoing mixtures should be reduced by 15 or 20 pounds and an equal weight of calcium arsenate added.

Nicotine will not volatilize rapidly enough for high efficiency

unless the application is made when the temperature is 70°F. or higher. But aphids often should be combated in cool periods.

To secure greater efficiency from nicotine at low temperatures, equipment has been designed that consists essentially of a tiny metering pump which injects nicotine solution into the exhaust pipe of a small internal combustion engine. The solution must be introduced at a point where the temperature is high enough for quick volatilization but not too high. Thence engine exhaust pressure distributes the warm toxic gas through a suitable boom.

Aprons (p. 175), effectively increase the percentage of kill. Nicotine insecticides disappear in a few days by volatilization and no objectionable residue remains.

Pyrethrum sprays and dusts are valuable insecticides which do not leave poisonous residues. They have been too costly for general commercial use but are very satisfactory for small areas and special purposes. Pyrethrum dusts should contain 0.5 to 1.0 per cent pyrethrins. The extracts usually are more expensive than the dust. The use of pyrethrum in vegetable gardening has been superseded to a large extent by less expensive rotenone preparations.

Rotenone insecticides, in the forms commonly used, are toxic to most chewing and sucking insects and to lower forms of life, but leave no poisonous residue after a few days exposure to air and light. For this reason, and for extreme though slow toxicity to many insects, rotenone has quickly become the most important insecticide for application on vegetable crops. Rotenone is effective, economical, and practically indispensable for use where arsenicals can not be applied without danger of harmful residues.

Rotenone insecticides are particularly effective against the Mexican bean beetle, the pea aphid, and the cabbage worm, and have come into general use to control a long list of other insects, including asparagus beetles, flea beetles, blister beetles, thrips, leaf hoppers, and cucumber beetles. As an aphicide, rotenone is effective for some species when sprayed on the insects as an extract or suspension, or when dusted on the plants while they are wet with dew.

Rotenone is applied most commonly in the form of dusts that are prepared from finely powdered derris root which contains, as usually sold, 4 to 5 per cent of rotenone, as well as other toxic ingredients. Powdered cube and timbo root also are used in the preparation of rotenone insecticides.

Rotenone dusts should be made to contain 0.5 to 0.75 per cent rotenone and may be purchased ready for use, or mixed at home by the method described under Nicotine, using talc, pulverized clay, gypsum, sulphur, flour, or other non-alkaline diluents. Loss of toxicity will follow when rotenone preparations are mixed with alkaline materials, for example hydrated lime or bordeaux mixture.

Derris root manufactured to pass a 300-mesh screen and containing 4 to 5 per cent rotenone may be used satisfactorily in spraying. Rates are 3 to 5 pounds to 100 gallons of water, with either 1 pound of powdered skim milk, 2 gallons of sweet skim milk, or 3 pounds of well dissolved soap. Caustic soap is unsuitable. Commercial preparations containing a suitable sticker are available.

Rotenone deteriorates upon exposure and is likely to remain effective longer when applied as powdered derris root either in dusts or suspended in sprays, rather than in the form of extracts. The extracts, however, have proved especially effective against some aphids.

Manufacturers' directions should be followed in spraying commercial rotenone insecticides, or the effective combinations of pyrethrin and rotenone, which are available ready mixed with suitable spreading agents.

Arsenicals, which are the most inexpensive stomach poisons, generally are used wherever the residues will not be dangerous. They may be applied as sprays or dusts and in combination with fungicides.

Lead arsenate is undesirable on most vegetable crops because lead is more persistent than arsenic as a residue and likewise is harmful to many plants.

Calcium arsenate is cheaper than lead arsenate, may be slightly less toxic in a few instances, but is more generally useful to the vegetable grower. The usual rates are 3 or 4 pounds to 100 gallons of water. It is recommended that an equal weight of air slaked lime be included, except in combination with bordeaux mixture. The procedure is to mix the dry arsenical to a paste and then wash this into the sprayer. Or the dry insecticide may be washed through the filler screen with a stream of water. Generally a spreader should be added as recommended below. Keep the agitator running while filling the tank.

Calcium arsenate dusts are mixed, as a rule, at the rate of 15 pounds of the insecticide to 85 pounds of the diluent, although a proportion of 20-80 is recommended for some purposes. Hydrated or air-slaked lime, very finely pulverized limestone, gypsum, or flour are common diluents, but lime is undesirable for dusting cucurbits because excessive burning of foliage often follows.

Magnesium arsenate is especially useful, until blossoming time, in controlling the bean beetle, because the danger of burning the foliage is very slight, less than with calcium arsenate (p. 397).

Spreaders for arsenicals.—The addition of about 3 pounds of casein spreader or of flour paste, or of a gallon of sweet skim milk, to 100 gallons, will increase the spreading and sticking qualities of

arsenicals. Soaps added to arsenicals are likely to result in the formation of arsenical compounds that will injure foliage.

Fluorines are used as dust or spray, especially against the bean beetle, flea beetles, blister beetles and the tomato fruit worm. A spreader is needed in spraying. The residue is objectionable on edible or marketed part of the plants.

FUNGICIDES

Bordeaux mixture is employed almost exclusively as a fungicidal spray in vegetable gardening and serves also as a repellent to some insects. The standard formula is 4 pounds of copper sulphate and 4 pounds of high-grade lump lime (or 6 pounds of hydrated finishing lime) to 50 gallons of water. Common variations are 2-2-50 for muskmelons, 3-3-50 for cucumbers, and 5-5-50 for celery where its blights are difficult to control.

Ready-mixed concentrated bordeaux may be purchased in dry or paste forms and is convenient to prepare for use. It is more expensive and less adhesive, however, than freshly mixed home-made material.

There are in vogue two common methods of making bordeaux mixture. The more convenient one, as described for making 100 gallons of spray, is to place 8 pounds of powdered copper sulphate on the screen of the spray tank, start the agitator, and wash the chemical into solution in the tank. Sufficient water is added to bring the volume to about 90 gallons. Finally, 12 pounds of high-

John Bean Mfg. Co.

FIG. 62.—Horse drawn, engine powered, 4-row sprayer for small and medium acreages.

grade hydrated lime are placed on the screen and gradually washed through the mesh with enough water to make the completed volume 100 gallons. The agitator should be kept running throughout the entire time of filling and spraying. This is the method of preparation now in most general use. It has been proved effective wherever adequate amounts of the fungicide are correctly applied.

Some authorities think that a slightly more adhesive and efficient bordeaux is made when the lime is supplied from a stock solution prepared by slaking burned lime capable of producing a quick hot reaction. The first step in this method is to make the stock solutions. A wooden or earthen vessel is required for the copper solution and a metal one for the lime solution. Unless the capacity of the vessels is known, they should be measured with water. Separate lots of copper sulphate and of lime are weighed out at the rate of one pound of each to a gallon of capacity of the respective containers. The wooden vessel is filled with water and the copper sulphate is allowed to dissolve from a clean, loosely woven bag suspended just below the surface.

Lime is placed in the other vessel and is slowly sprinkled or splashed with water until slaking begins. As the process becomes more violent the addition of water is accelerated just enough to prevent the formation of dust. The mixture is stirred vigorously until there are no dry spots or lumps. As boiling subsides the mass should have the consistency of thick paste. Stirring should continue until the material is perfectly smooth. Then water may be added to the required amount. Ground limestone or air-slaked lime is worthless for making bordeaux mixture. Hydrated lime may be used. It is simply stirred into a paste, beginning with very little water.

The separate stock solutions will keep indefinitely, although it is necessary to protect them from evaporation or to make up the loss by adding water. The lime stock must be stirred thoroughly before it is used.

Mixing should not take place until the sprayer is ready to start, because bordeaux mixture begins to deteriorate as soon as it is made. To make the 4-4-50 formula, the lime stock is strained into the sprayer with the aid of a stream of water playing on the screen, at the rate of one gallon of the stock to 12½ gallons of tank capacity. Water is added until the tank is almost full. Then vigorous agitation must be provided by starting the engine, or by stirring, in the course of which an equal measure of copper stock is added. Finally, water is added to fill the tank. Properly made bordeaux mixture is sky-blue in color, very finely divided, and free from curds.

To prepare a small quantity of bordeaux mixture conveniently,

dissolve ¼ pound copper sulphate in 1½ gallons of water in a wooden or earthen vessel. Slake ¼ pound of lime in another vessel and dilute to 1½ gallons. Then pour the two solutions simultaneously into a third vessel. Further dilution is not required.

As mentioned hereafter, arsenicals, nicotine, or both may be combined with bordeaux mixture.

Copper-lime dusts are the dust equivalent of bordeaux mixture, wherever dusting is preferred to spraying. If desired they may be prepared on the farm in a homemade or purchased mixer by thoroughly mixing 15 or 20 pounds of very finely ground monohydrated copper sulphate with 85 or 80 pounds of the best grade of hydrated lime. It is absolutely essential for proper reaction between the materials that copper-lime dusts be applied when the plants are wet. They become almost worthless if they are applied when the foliage is dry. The materials must be directed to reach and cover all surfaces of the plant.

Other copper bearing fungicides are attracting attention as substitutes for bordeaux mixture under certain conditions. They may prove particularly useful for tomatoes and cucurbits, on which crops bordeaux mixture often is objectionable because of its effect in increasing the rate of transpiration. They are also useful, on tomatoes for example, because they leave less noticeable residue than does bordeaux mixture. In a number of tests, especially where blight conditions are not generally severe, they have produced larger yields than bordeaux mixture.

The so-called "insoluble copper compounds" are sold under a variety of trade names. Cuprous oxide in the form of red copper oxide and yellow copper oxide, copper oxychloride, and copper zeolite are commonly offered. In spraying a sticker is likely to be needed unless it was included in the commercial preparation.

The manufacturer's directions should be consulted. Ordinarily about 2 to 4 pounds of the material are used with 100 gallons of water and, if it was not previously included, 2 pints of lethane or other spreader. For severe blight conditions the quantity of material is increased by half. If necessary a suitable insecticide can be included. Continuous agitation should be maintained throughout the time of filling and spraying.

A typical dusting formula that is especially effective on cucurbits is 1 pound of the copper compound with 7 or 8 pounds of cheap flour or other diluent and 1 pound of calcium arsenate.

Combinations of insecticides and fungicides.—It is often possible and advantageous to combat both insects and diseases at one application. Arsenicals and nicotine may be added to bordeaux mixture without soaps or spreaders and in the quantities prescribed for an equal volume of water. For dusting, where both chewing and

sucking insects are present, a standard formula is 80 pounds of hydrated lime, 15 pounds of calcium arsenate, and 5 pounds of nicotine sulphate (40 per cent). Or, to combat blights and chewing insects, copper-lime dust may be made up of 60 pounds of hydrated lime, 20 pounds of monohydrated copper sulphate, and 10 pounds of calcium arsenate. Many combinations are possible (pp. 166, 168, 171). Alkaline materials are unsuitable to mix with rotenone.

SPRAYING AND DUSTING

Whether spraying or dusting is likely to be more expeditious depends upon a number of circumstances. Many growers find it advantageous to have equipment for both methods.

With some exceptions, insects may be controlled equally well by either method of application but diseases, under average conditions, are likely to be controlled more effectively when the fungicide is applied as a spray at a pressure of at least 250 pounds to the square inch. However, excellent control of celery and potato blights, for example, often is obtained by liberal, thorough application of fungicidal dusts at times when the plants are wet with dew. Rotenone insecticides possibly may be more effective against chewing insects when applied as dusts. Dusting, with nicotine, is the most effective means of killing aphids in curled, dense, or very low-growing foliage.

Because satisfactory pressures can not be maintained with hand-powered sprayers, dusting is preferable, as a rule, for the home garden and even for larger areas whenever the purchase of a high-pressure sprayer is impossible. Hand-crank dusters are quicker and more convenient than sprayers in the limited areas of gardens and plant beds and are sufficiently rapid and efficient to find general use in market gardens. Dusts are often applied by hand to large fields of cucurbits, beans, and cabbage or related crops and are economical of material for widely spaced plants during the early stages of growth.

In the sizes for field use the much lighter-weight duster permits applications when the ground is too soft to support heavy sprayers, reduces packing at all times, and is an advantage on hilly lands.

The large requirement of water in spraying, usually more than 100 gallons to the acre, is a serious disadvantage where the fields are far from the water supply or where this is limited.

On the other hand, the expense of dusting is often higher because the cost of materials required to the acre usually is larger than in spraying. The difference may amount to a considerable sum where large acreages are involved. Although spraying probably is more widely employed than dusting, the latter method is most ad-

vantageous in many situations. To choose equipment that will prove both economical and efficient one must consider the nature of the crop and of the pests, the water supply, the acreage, labor supply, type of soil, and topography.

Hand equipment.—The small atomizer sprayers and plunger-type dusters are useful only for small gardens, and are not fully satisfactory there. Shaker dusters made of cheese cloth, or of cans with many holes in the bottom, are fairly satisfactory where it is sufficient to dust the upper surfaces, as with rotenone dusts on cabbage, or where the dust that strikes the ground swirls underneath young plants, as on small cucurbits.

The common compressed-air knapsack sprayers are suitable for gardens of ordinary size and for attacking isolated infestations in large fields. The hand-operated fan-type dusters, as previously suggested, however, are more popular and satisfactory and much easier to handle than sprayers of similar capacity. The bellows-type knapsack dusters are most useful for crops that are planted in hills.

Power equipment.—Power sprayers and dusters may be divided into four general classes:

Hardie Mfg. Co.

Fig. 63.—Eight-row sprayers, engine powered and horse or tractor drawn, will cover 15 to 25 acres a day with convenient facilities for filling.

(1) Traction powered machines are the least expensive type. The power to drive the spray pump or duster fan is transmitted from one of the wheels that carry the machine. With 3 nozzles to the row, four-row spraying is about the limit of capacity of traction machines and may be accomplished quite efficiently, when the team or tractor is strong enough to draw the outfit at a fairly rapid pace.

Pressures over 250 pounds are seldom practicable on account of the increasing draft as the pressure rises.

(2) Engine powered machines are required where it is desired to cover 6, 8, or more rows thoroughly at one passage. The pump or fan is powered by a small engine mounted on the machine. Under favorable conditions outfits of this class will cover 10 to 15 or more acres a day.

As a general guide in purchasing row-crop sprayers, the pump should deliver about 2½ gallons a minute for each row. To maintain the desirable working pressures of 300 to 500 pounds to the square inch, the engine should develop at least one horse power for each row. For example, a popular 8-row 24-nozzle celery and potato sprayer carries a 20-gallon-per-minute pump and either an 8 or 12 horse power engine.

(3) Power take-off machines are increasing in popularity among growers who use row-crop tractors. The tractor engine both draws the outfit, and, through a flexible shaft, transmits power to the pump or fan. As one less engine need be maintained, purchase cost is lower. In general, tractors developing 12 H.P. at the drawbar will handle 6-row, 18-nozzle, power take-off sprayers and those developing 20 H.P. will handle 8 to 10-row outfits.

(4) Automotive machines, in which both engine and sprayer are mounted in one chassis, are extensively used among growers with large acreages. They are especially useful where fields are widely distributed or the distance to water is great. Motor truck chassis of suitable size are commonly used. Power dusters, because weighty water is not carried, require less power for propulsion and often are built on light, self-propelled or trailer chassis.

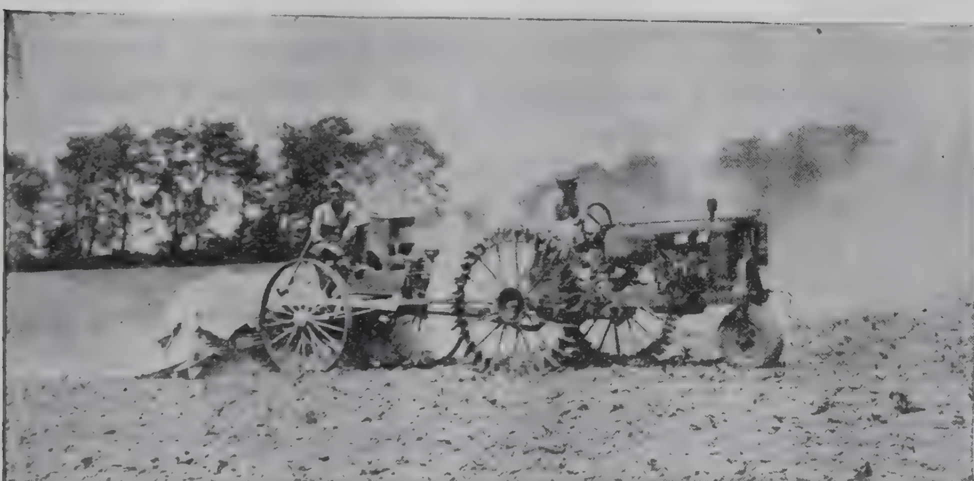
Spray booms and nozzles.—For most row crops the boom should be designed to direct 3 nozzles on each row, one directly above and one on each side. It should be adjustable as to elevation and to center the cones of spray on the row, or to direct them at any desirable angle. Poor adjustment of nozzles is very common. Figure 61 illustrates a properly designed and adjusted spray boom in operation. Special booms may be necessary to meet unusual problems, as in spraying closely planted, low-growing crops.

Nozzles should be adapted to the pressure and capacity of the pump. The so-called potato nozzles are satisfactory with the larger machines. It is very important, however, to use discs with apertures of correct size. Discs wear out rather rapidly and must be replaced periodically. Oversize apertures lower pressures, and produce a coarse spray which wastes material and sometimes injures foliage.

Dust nozzles and hoods.—It is extremely important that multiple row dusting equipment be designed to deliver an equal quantity

of material and volume of air to each outlet. As a rule, two nozzles are used to the row, one on each side; three nozzles may be required for certain conditions, however, and one may do for many others.

To limit the dispersion of the dust and to retain the enveloping cloud in close proximity to the plants, various kinds of hoods, aprons, or muslin trailers are provided. By such devices great increases in efficiency of dusts are secured and much smaller quantities of material are required. For aphids some use an apron 100 feet long. If the rate of travel is 100 feet or 200 feet a minute, the dust is retained one minute or one-half minute respectively. To cover a 15-foot strip the muslin should be cut 20 feet wide on account of narrowing with stretching.



King Farms Co.

FIG. 64.—Dusting with hood and trailing apron greatly improves efficiency under certain conditions, especially with peas and generally in the control of aphids.

Even with small hand-dusters, growers can employ the hood principle to kill insects on young cucurbits or on large, valuable, early-set tomatoes or eggplants. Covers are prepared by placing paper inside one basket and nesting a second basket into the first to hold the paper in place. The lined baskets are placed in a row over the hills or plants to be protected. In turn each is raised slightly to receive a puff of the insecticide and then is lowered immediately. In a few minutes they can be moved to the next row.

General consideration in spraying and dusting.—Spraying and dusting involve considerable expenditures for equipment, materials, and labor. The entire investment is jeopardized if details that may appear inconsequential are overlooked. The material and formula must be appropriate. Concentrations and procedure of preparation must be correct. The manner of application must be suitable for conditions.

Timeliness.—Preparedness is essential. In too many instances no preparation is made in advance and, when the pests appear, it is impossible to secure materials quickly, or the equipment is not in order for immediate action. Timeliness also requires close, daily observation to detect attacks in their early stages, and strict observance of schedules where routine applications are necessary.

Frequency.—In very rainy weather, when many disease organisms are especially active and plant growth is rapid, it may be necessary to spray or dust as often as twice a week to maintain a reasonably complete protective film. In normal weather application at intervals of one or two weeks usually is satisfactory.

Thoroughness.—Probably no factor is more often overlooked than the provision of enough nozzles and their adjustment to apply a completely enveloping film of the insecticide or fungicide. Maintenance of adequate pressures is equally important in securing effective coverage and is dependent upon systematic servicing and maintenance of the equipment. The quantity of material applied has an important bearing on thoroughness. Amounts vary greatly with the size and character of the crop. Ordinarily they range from 75 to 150 gallons of spray and from 20 to 60 pounds of dust to the acre. Smaller or larger amounts may be required under special circumstances. Acceleration or retardation of engine speed or the rate of travel are convenient means of regulating the amount of application to suit the size and density of growth and the degree of infestation.

King Farms Co.

FIG. 65.—An autogiro or aeroplane may be used in dusting large fields. Precaution must be observed to avoid depositing objectionable residues on adjoining properties.

Precautions for operators.—Although the handling of spraying and dusting materials usually is not considered to be dangerous, precautions should be taken, particularly to avoid breathing the concentrated forms and to prevent the materials from entering the eyes. Poisons should be stored under lock.

The residue problem.—The publicity which often attends condemnation of a single car or truckload of vegetables, on account of illegal residues, seriously affects public confidence in the safety of vegetables as food and unquestionably reduces demand.

It should be noted, in controlling insects, that calculation of legally permissible residues includes those on attached leaves or stems, as well as on the preferred edible portions. For example, absence of objectionable residues on heads of cabbage or curds of cauliflower will not prevent condemnation if excessive amounts are present on the protecting leaves.

With such crops, the program that often combines safety and economy is to spray with arsenicals during the early stages of growth as thoroughly as may be necessary to keep the insect population very small, and to use non-poisonous insecticides, such as pyrethrum or rotenone, after the parts that go to market begin to form.

GENERAL CROP INSECTS

There are certain insects which usually attack only one crop or closely related crops and these are discussed in the chapters devoted to the several groups of vegetables. Other insects attack many different plants; their control is considered here, briefly and in alphabetical order.

Aphids or plant lice are of several kinds and attack many garden crops. During most of the growing season the young are born alive, mature in a few days, and in turn each may bear several young daily. They suck the plant juices and often are unnoticed until the leaves begin to twist and curl. Because they may multiply with extreme rapidity and work inconspicuously at first, heavy infestations often develop and serious damage frequently occurs before they are noticed. The grower must be alert to detect attacks promptly so that control may be undertaken while it still may be effective.

Extracts of pyrethrins and rotenone and suspensions of finely ground derris root are effective aphicides under certain conditions, especially when applied as sprays, or as dusts when dew is on the insects (p. 167).

Nicotine, however, has ranked as the leading aphicide for many years and is used with equal success, under appropriate conditions, as a fumigant, a spray, or a dust.

To be satisfactorily effective as a spray at least 95 per cent of the aphids must be contacted. Where the habit of growth or curling of leaves makes general coverage impossible, nicotine dusts will prove more effective and should be applied during hot, dry, calm hours and with the advantage of hoods, aprons, or trailers (pp. 175, 389). Rates of application have been suggested (pp. 166, 176).

Blister beetles, sometimes called army bettles because they often migrate in swarms, are elongated, somewhat soft-bodied, long-legged, clumsily flying insects that are black, gray, brown, yellow, striped, or spotted in different species. When numerous they cause serious damage and are difficult to poison. In small gardens they may be knocked into a pan containing a little oil, or even may be picked by hand. Crushing or rough handling may cause blistering of tender skin. Calcium arsenate is effective if applied when the first beetles appear (p. 168).

Cutworms often create havoc by cutting off plants near the surface of the soil. They are likely to be abundant in sod land and in rich garden soil. Avoid newly turned sods for the setting of plants and practice fall or very early spring plowing. Keeping poultry on the land before planting, and the use of heavy paper collars, extending an inch or two above and below the surface of the soil, are practicable in small gardens. Poisoned baits are an effective remedy. They should be scattered about the garden late in the evening, or, to protect the birds, they may be placed under small boards or buried shallowly close to the plants. A standard bait is prepared by mixing dry, ¼ pound of white arsenic or Paris green and 5 pounds of bran or corn meal. Into this is stirred a pint of molasses diluted with only enough water to make a stiff mash. Inclusion of the juice and ground rind of orange or lemon will increase the appeal of the bait. Another formula is 2 quarts 40 per cent liquid sodium arsenite diluted with 10 gallons of water and stirred into 100 pounds of bran.

Earthworms are usually more beneficial than injurious but may be controlled when necessary by drenching the soil at the rate of one quart to the square foot with a solution of one ounce of corrosive sublimate in 20 gallons of water. Finally, the soil should be watered very thoroughly.

European corn borer and common stalk borers feed in the stalks of many weeds and vegetables. Control depends upon keeping down weeds in and adjoining the garden and in plowing down or otherwise destroying the stalks in the fall or in the spring, before the middle of May in most localities.

Flea beetles are little, black, jumping insects which often become especially destructive on transplants or seedlings in early spring. They usually eat many tiny holes in the leaves and some-

times devour patches of the leaf tissue. The larvae of some species may feed on the roots. Fall cleaning-up of refuse and trash, which may harbor the beetles, and heavy dusting of the plants with lime at frequent intervals are helpful in the garden. Bordeaux mixture is effective with the addition of arsenicals, or the latter may be applied alone in dust or spray. A 20-80 copper lime dust also is effective. Rotenone dusts are especially convenient and effective in protecting newly set plants. Frequent applications may be required to keep the plants free from the insects.

Grasshoppers are combated in the garden by poison baits as described for cutworms.

Japanese beetles, shiny bronze-green insects about ⅜ inch in length and of stocky proportions, are voracious feeders that may attack a number of vegetable crops. Spraying with 5 pounds of hydrated lime, 1 pound of flour, and 3 pounds of lead-oleate-coated arsenate of lead, is commonly recommended.

Leafhoppers are delicate slender insects, scarcely one-eighth of an inch in length, often pale green or brown in color. They are sucking insects which commonly attack potatoes and sometimes beans, beets, or other vegetables, producing a characteristic curling and sometimes browning and dying of the edges of the leaves. Contact insecticides are recommended, especially pyrethrum sulphate, although the usual spraying program, including bordeaux mixture and arsenicals, keeps leafhoppers in check on potatoes.

Millipedes or thousand-legs may feed to a serious extent on germinating seeds, root crops, potatoes, or even the above-ground portions of some vegetables. Poison bait, as described for cutworms, is effective.

Plant bugs, an example of which is the well known stinking squash bug, may attack the tender growing parts of various vegetables. Spraying or dusting with nicotine, pyrethrum, or rotenone is most effective during the cooler parts of the day when the insects are active. Sanitation and trapping are helpful (pp. 162, 163, 470).

Red spiders are tiny mites which suck the juices from the leaves of many plants, eventually causing the foliage to present a yellowish or scorched appearance. They are especially serious on cucumbers and tomatoes in the greenhouse, where the most common method of control is forceful spraying of the leaves, particularly the under sides, with water at high pressures. Red spiders also may be injurious to various vegetables in the field. They are difficult to control by ordinary spraying with contact insecticides but certain combinations of pyrethrum, rotenone, and an activator have proved very effective. Dusting sulphur is of some value in combating red spiders.

Thrips are slender-bodied, whitish to brownish insects, so minute that they are barely visible to most eyes. They are particularly destructive to onions and cause the so-called "blighting" that often results in premature dying of the plants. Thrips also are common on cabbage and some other crops but the injury is not always serious. Applications of tartar emetic or of nicotine, preferably as a spray, or of rotenone are fairly effective. The first application should be made as soon as the insects are detected and one or more should follow at intervals of a week (p. 321).

White grubs are the larvae of the May or June beetles. Root crops, potatoes, and corn are especially subject to their attacks, but they feed on roots of nearly all vegetables. They become very numerous in old grass land and, for this reason, short rotations that retain sods not more than two years, and preferably only one, are advisable where vegetables are to be grown. Fall plowing, to expose the larvae to their predators, and to the elements, is very effective. These measures, and the avoidance of infested sod land for planting potatoes or other vegetables of which the market value is directly injured by attacks of white grubs, are the only feasible means of control.

Wireworms, the larvae of click beetles, are slender firm worms one-half inch or more in length. When numerous they devour many germinating seeds and may destroy completely the market value of root crops and potatoes. Preventive measures include keeping the vegetable land in cultivated crops, rather than in sods or heavy cover-crops, during late spring and early summer when the adults are laying their eggs, and in early fall plowing before the wireworms have migrated deeply into the soil. Like white grubs, ovipositing occurs about June, the larvae live in the soil usually three years, and are likely to become very numerous in old sods.

It has been suggested that control can be secured in infested gardens by baits. These may be prepared of fresh clover leaves drenched with an ounce of Paris green in a gallon of water or of poison corn meal or bran mash as described for cutworms (p. 178). Baits should be distributed around the plants late in the day to avoid drying. It has been recommended also that poison baits be distributed in the garden early in the spring, and that 2 per cent nicotine dust be sown in the rows with the seed. Another method, for small gardens, is to apply pyrethrum and soap solution directly to the soil about the plants.

Slugs or snails prefer to inhabit damp areas and feed voraciously on tender vegetables, often eat large ragged holes, and sometimes injure the hearts of celery. They hide under vegetation or trash during bright days and feed principally at night. Their work may be identified by trails of glistening slime wherever they travel.

The most common remedy is to dust lime over the soil and plants. An effective method is to dust with hydrated lime at night, when many of the feeding pests will be contacted directly. Salt, soot, sifted wood ashes, or other dusts also are used. Another device is to provide small boards as hiding places, under which the slugs may be discovered and killed. The poison bait described for cutworms is effective.

Weevils in beans and peas may be destroyed by fumigating with carbon bisulfide in the fall. Place the seeds in a perfectly tight container such as a metal drum or barrel, but do not fill it quite full. Pour the carbon bisulfide, one ounce to the bushel of seed, into a pie pan or shallow dish on top of the seeds and close tightly for 24 to 36 hours. In large compartments the dose is 3 pounds for 100 cubic feet of space. The temperature should be at least 70° F. to secure effective results. Carbon bisulfide is very inflammable. Keep it away from open lanterns or fires, and do not permit workers who are handling it to smoke. The planting of weevil-infested beans invites infestation of the new crop. Another method is to heat the dry beans to 135° F. for 3 or 4 hours.

GENERAL DISEASES

Specific diseases of vegetable crops are confined as a rule to a single crop or group of crops and are considered later in such connections. A few diseases are troublesome with a number of crops.

Damping-off, caused by species of Rhizoctonia and Fusarium, often becomes epidemic in badly managed plant beds and may attain importance in the field, especially during warm, moist periods. Its control in plant growing has been discussed (p. 51) and protective seed treatments have been described (p. 25). Clean deep plowing and rotation are helpful in the field.

Root-knot or nematodes, caused by a microscopic parasitic eelworm *Heterodera maroni*, is most destructive in sandy soils and in the South. Even in the North serious loss may follow the use of infected plants. It does not usually survive severe winters and is most familiar to northern growers as lumpy galls on the roots of greenhouse tomatoes and cucumbers. Most vegetables are susceptible but nearly all cultivated grasses and cereals are resistant. Losses can be reduced by arranging the rotation to include a two-year period in which only the resistant crops are planted. Control under glass is accomplished by soil disinfection (pp. 44, 485, 486) with extreme care to avoid recontamination.

Bacterial soft rot may affect a number of vegetables in field, storage, or transit. Rotation, careful handling to minimize bruis-

ing, and disinfection of storages with formaldehyde (pp. 426, 465) are recommended.

Sclerotinium rot, in the North, and Sclerotium rot, in the South, are combated by rotation and by plowing down undecayed organic matter as deeply and cleanly as possible a considerable time in advance of planting.

Stem rot, root rot and some other diseases are discussed with the crops which are attacked most severely.

XI

HARVESTING, PACKING, AND MARKETING

HARVESTING and packing are the initial steps in distribution to the consumer. They present the first opportunity to impair, or to conserve and preserve, the natural goodness of well grown vegetables. Both the success of the grower or the group, and the expansion and maintenance of demand are particularly dependent upon the exercise of skill and diligence in harvesting and packing. Arrival at the market and on consumers' tables with but slight deterioration of appearance and of quality can be assured, in large part, by correct methods and management before the produce leaves the farm.

The consumer's interest.—In grading and packing, the grower, who naturally thinks in truck loads or car loads, also should be guided by the point of view of the housekeeper who thinks in terms of final units and condition. To her, if she happens to obtain an unsatisfactory cabbage or muskmelon, it is of no importance that ninety per cent of the specimens in the shipment were desirable. If she unfortunately secures overmature or heated peas or sweet corn from a careless grower or store-keeper she may conclude that good quality vegetables are unavailable. When served on the table no one asks for a second helping and there is no request for the same vegetable the next meal or the next day. Thousands of experiences of this kind in a great city reduce subsequent purchases. Poor quality, which necessarily results in slow sales and low prices, often is an important factor in development of glutted markets. When the vegetables are excellent, the family is pleased, the housekeeper tells the neighbors, demand increases, and movement and prices are supported.

HARVESTING

Timeliness in harvesting is of utmost importance in managing perishable crops. Securing prime quality and avoiding loss usually demand promptness. For example, a single day's delay in hot weather may result in serious deterioration of peas or a total loss of head lettuce. Delay, when destructive frosts or freezes may occur, frequently causes injury or loss of crops.

Frequent gathering of tomatoes, melons, beans, or other vegetables which mature progressively is required to avoid losses from

overmaturity of some specimens and to make a pack of uniform stage of ripeness.

When harvesting garden crops, consideration should be given as far as possible to soil and weather conditions. Many vegetables have better carrying quality when they are gathered while dry. Heavy soils are seriously injured if tramped or disturbed when wet. This, however, is often unavoidable. When the grower markets produce every day during the summer he must gather it regularly without regard to the weather.

Organization in the field.—It is imperative to have an alert foreman who is thoroughly familiar with every detail of harvesting and well qualified to direct men. It is usually possible to assign each laborer to one or two rows, and thus place definite responsibility upon each person. If baskets are used, an ample supply should be kept close at hand. When the force is large it may pay to have one worker see that an empty basket is within the reach of each picker the moment it is needed.

Associated Seed Growers, Inc.

FIG. 66.—Well organized harvesting of carrots.

Special roadways are necessary in collecting crops which are not harvested at one time. In many cases planting distances can be adjusted to permit the wheels of vehicles to straddle a certain number of rows. Occasionally earlier maturing varieties or crops may be planted on the strips wanted for roads.

Low platform wagons that are sometimes equipped with springs or pneumatic tires, and motor trucks are widely used in collecting vegetables from the field. Wheel-barrows with large boxes are convenient in very small plantings.

An especially important consideration in the management of workers is to eliminate rough handling of the vegetables. Needless bruising or crushing in the course of harvesting and packing results in extensive direct damage and, in addition, is a principal contributory cause of decay in transit or storage.

A matter of equal urgency is the prevention of wilting, heating, and exposure to sun during the interim before the vegetables are transported to the packing house or market. Neglect in this connection causes serious losses in quality and appearance (p. 435).

PREPARATION FOR MARKET

Packing in the field.—When washing and specialized grading are unnecessary, packing in the field may be both satisfactory and economical. For example, pickers may be trained to pack only first-grade beans, peas, or spinach, and can be held to high standards of workmanship by pencil marking each person's initials or pay number on the rims of baskets as issued. Cabbage and corn often are graded and packed in crates in the field, as harvesting proceeds. Vegetables packed in the field usually are hauled directly to cars or market. If they are to be held for a time they should be removed to a cool building or shaded place.

Bunched vegetables generally are graded sufficiently and tied as they are pulled, although a more fancy but usually costlier pack can be made by washing them and then bunching them in the packing house.

A serious objection to field packing is that the vegetables often go to market badly graded and improperly trimmed or cleaned, entirely unsuitable to compete advantageously with prevailing high standards. Close supervision is necessary to maintain consistently high standards or to gain economies when packing certain vegetables in the field.

Facilities for packing.—With the exception of truck farmers who specialize in crops that can be packed in the field, commercial vegetable gardeners must have facilities for packing. The individual grower usually provides these to meet his own requirements, although large-scale centralized or community packing houses are increasing in importance. By their operation the entire product of a locality can be packed to a uniform standard and trademark. The foreman of the individually owned packing house, however, can maintain equally high standards by thorough organization of the work and rigid inspection.

In some cases it is convenient to have a cheaply constructed shed in or near the field, although there are many advantages in a permanent house which, with office space and telephone, may con-

stitute the center of activities and be the headquarters during the market season. The building should be conveniently located, ample in size, and well lighted, and should have a concrete floor sloping gently to drains. Every facility and convenience should be provided for speedy handling of each crop. The elevation of the floor should permit unloading and reloading of vehicles at a level with the floor. For extensive shipping by rail the packing house should be located on a siding.

FIG. 67.—Where the size of the business does not warrant expensive equipment, a strong stream of water is satisfactory for washing bunched roots and celery. Convenient loading platform at left.

Investment in a suitable number of hand trucks, often called grocery trucks, or a lift truck and several homemade or purchased skids or platforms, will save a great deal of labor where large volumes of crops are handled. In loading standard packages the 3 by 5-foot size is most convenient.

Room in the loft, at an end, or in an adjoining shed, is necessary for storage of packages. There must be an adequate supply of water at good pressure if the activities include washing. Tables of convenient height, often of special design, are indispensable.

Washing equipment should be given special consideration. Tubs or open-top tanks are useful for certain purposes, even when mechanical washing equipment is at hand. Hose and nozzle, possibly of 1 to 1½-inch size where the volume of water is ample, are used commonly for washing racks of celery or bunched vegetables, which may be placed to advantage on platforms or tables of slats or screen. Washing outfits with special high pressure pump, hose, and nozzles, as developed for automobile washing, provide exceptionally

thorough cleaning, although it is necessary to handle the bunches individually.

For washing cut-off or topped root crops, home-made or purchased rotating drums are very satisfactory. Many growers of spinach or lettuce have basket dipping machines which convey the packages through one or two tanks and are useful in flooding out some of the sand, and in precooling when the water is kept very cold.

The Deming Co.

FIG. 68.—Washing with high pressure spray from specially designed adjustable nozzle. A popular method with bunched root vegetables, green onions, and celery. Note deep tub, and tying machine nearby.

Larger growers and centralized packing organizations commonly use more or less elaborate conveyor-type washers in which the vegetables, on a moving screen or slatted belt, are carried through chambers where they are subjected to vigorous sprays from all angles, above and below. Extension of the conveyor belt beyond the washing chamber provides a moving table for the activities of inspectors and graders. Fans sometimes are employed to remove loose leaves and dirt from snap beans, or to dry them when washing is required.

Rubber boots and aprons should be included in the packing house equipment.

General procedure.—After the vegetables are received at the packing house several operations may be necessary before they can

be ready for packing. Many require trimming, removal of unsightly leaves, bunching, or sorting before they are packed. Mechanical tyers operated by foot-pedal or electric motor are used by many growers. Rubber bands are often used for tying.

Thorough washing is generally regarded as necessary for celery, lettuce, asparagus, and all the root crops, and is considered an advantage under certain conditions for many other crops.

Mathews Conveyor Co.

FIG. 69.—Conveyor washers have large capacity.

Vegetables which are bunched may be washed before tying, but the most common practice is to wash after tying, because the work can then be done more rapidly. When they are not much soiled, the stream from a hose may be sufficient and this is decidedly more efficient in case of root crops if great care is taken from the moment they are pulled to prevent air from drying the dirt.

Water is used mainly for cleaning, but it gives many vegetables a fresh, bright appearance and prevents them from becoming wilted and withered before they reach the market. Plumpness also is maintained, as when the green pods of peas are immersed in cold water a few moments before packing for local markets. Whatever

the vegetable, to make a favorable impression on the buyer it must be clean, although it is not always advisable to use water freely. Tomatoes, cucumbers, watermelons, muskmelons, squashes, peppers, and eggplants sometimes can be wiped with a damp cloth to secure the required cleanliness and to avoid the disadvantages of wetting such vegetables without facilities for drying them immediately.

Grading.—Careful grading is imperative, especially for discriminating markets. Uniformity in size, shape, color, markings, and ripeness counts for more than most growers realize. Eighty packages of properly graded vegetables often will bring more money on the markets than 100 packages ungraded. One inferior specimen or package may repel a dozen buyers.

The number of grades necessarily varies with the market and the vegetable to be graded. It is often profitable to make two market grades, according to size or other points of merit. Only one grade, however, is usually made of peas, beans, spinach, and some other vegetables, and the specimens below standard are discarded. The work of grading should be most carefully supervised in order that the established grades be maintained. Damaged and imperfect specimens should be discarded. Even the lowest grades must be sound and usable, a fair value at the price asked.

Growers who desire information concerning standard grades, or who wish to secure shipping point inspection and official certification of grades, should communicate with the Bureau of Agricultural Economics of the United States Department of Agriculture and their State Bureau of Markets.

Precooling has come to be a standard practice in the preparation of many vegetables for market, particularly those with a great tendency to generate heat in the package or to ripen too rapidly, such as peas or cantaloupes. The process consists of reducing the temperature to as low a point as the nature of the vegetable or the facilities will permit, preferably 45 degrees F or lower. It is widely employed in preparation for distant shipment and may be accomplished by various suitable means either before or after packaging or even after loading cars. Because respiration is retarded greatly, at low temperatures, thorough precooling may overcome most of the self-heating tendency of certain crops (p. 435). Of course refrigeration in transit may be required to counteract outside heat.

Although large packing houses may employ specialized precooling equipment, practical, inexpensive precooling of many vegetables can be accomplished by immersion in tanks containing very cold water. The length of time required to remove the heat from the center, when the vegetables are treated in the packages, may be determined by test. Ample amounts of ice or submerged re-

frigerator coils must be provided to keep the water temperature very low.

Vegetables which should not be wet may be precooled in cold storage chambers by piling the packages to permit free circulation of air. But nearly all vegetables will stand wetting if they are kept cold. Thorough precooling and packaging in paper-lined, closed containers effectively retard ripening processes and deterioration of quality.

PACKING

Use of ice and paper.—An effective means of conserving quality and preserving the attractive condition of peas, spinach, lettuce, bunched vegetables, broccoli, celery, sweet corn, and some others is to line the packages tightly with moisture resistant paper, and add crushed ice liberally as packing proceeds. This practice may be employed alone or in conjunction with precooling. When ice is used very freely in the packages and they are transported with refrigeration, little deterioration will occur in several days. If, however, packages are exposed to so much heat that the ice melts, the wet vegetables soon become warm and decay.

Waxing to retard drying out and withering, and to improve appearance, is gaining importance with certain vegetables, especially cantaloupes, root vegetables, cucumbers and tomatoes for distant shipment. The wax is generally used as a manufactured emulsion which is diluted with water according to the maker's directions. Different emulsions may be required for different vegetables and the material must be non-toxic and without noticeable flavor. With conveyor packing equipment the application is generally made by immersion and fans can be used for rapid drying. On a small scale a convenient method is to place the cleaned vegetables in wire baskets, dip them, and allow the excess material to drain back into the vessel. In a few minutes the vegetables will be dry. The very thin film remaining is scarcely apparent. The cost is not excessive.

Packages.—Many factors must be considered when selecting packages: (1) The most advantageous size must be determined. This is an age of small packages, which are gaining in popularity among both growers and buyers. As a rule, produce sustains less injury in transportation when marketed in small packages, and arrives in more attractive condition. Retailers prefer small packages because the contents can be resold before spoilage occurs, and a new package is opened more frequently for display. Consumers prefer them for convenience in handling and usableness of amount.

(2) The appearance of the package counts for much in making satisfactory sales. If it is neat and bright instead of dull and dingy, the display will be more pleasing.

(3) The package must be a secure carrier. It must not break or come apart in handling or in transit, or be crushed in the bottom tiers when ranked in loading. Both are common causes of loss.

(4) Adaptation to the crop and the season is essential. Typically different requirements are: rigidity to prevent crushing of tomatoes; very free ventilation for melons and early cabbage; moderate ventilation for beans and potatoes; protection from drying for spinach, lettuce, and bunched vegetables; and protection against

Paterson Parchment Paper Co.

FIG. 70.—Paper linings and crushed ice are a necessity in packing many vegetables for long-distance shipment. Even with nearby markets profits often can be increased by their use.

heat or cold. The package also must be adapted to the size, shape, and solidity of the vegetable to be packed.

(5) It should be convenient. The nesting, loading, and handling qualities of a package are important considerations. It is a great convenience to be able to nest empty packages. When filled they should be loaded with economy of space and should stand without danger of upsetting or shifting in transit. For local and retail trade, neat, attractive baskets with handles usually appeal to buyers.

(6) Cost is an element to be considered, but the cheapest packages may be the most expensive in the end. A safe policy is to buy the best as cheaply as possible.

Second-hand baskets probably are used more generally than their apparent economy would justify. Their use, however, is practicable and advantageous under many conditions, particularly when delivery is made direct to the consumer or retailer rather than to large receivers who must resell in the open market. But dirty, unsightly packages must not be used, and original markings should be obliterated or covered with new labels.

(7) Demands of the market must be recognized to a certain extent; that is, if a market has become accustomed to a particular style of package, its use is likely to be an advantage. A superior package and pack, however, attract attention in any market.

Many different types of packages are available. Selection is determined, as a rule, by the usage of the community. Round bushel baskets probably are used most universally both for shipping and selling locally. Bushel hampers are popular for shipping peas, beans, cucumbers, and many other crops from the southeastern states. The 5/8 and 1/2-bushel stave baskets are widely used in New Jersey and some adjoining areas. Flat bushel boxes are preferred by many New England growers. In the lake states the so-called square braid baskets in various sizes are employed to market a long list of vegetables. In many localities 12-quart climax (grape) baskets are used for packing tomatoes; in others, however, flat lug boxes are increasing in favor for market tomatoes. The barrel continues to be an important container for early potatoes, sweet potatoes, and, in many markets, cabbage. Special crates are available for asparagus, cabbage, cauliflower, celery, and melons. The western lettuce crate is also used extensively, both new and second-hand, for carrying early cabbage, bunch vegetables, celery, and many other vegetables. Other popular second-hand packages are the northwestern apple box and the wire bound orange crate which may be obtained at small cost in sound, clean condition. Sacks are used extensively for potatoes, onions, and late cabbage.

Under the prevailing system of licensing, factories are permitted to manufacture baskets of standard sizes only.

Packing.—There are three main considerations in packing vegetables after they have been cleaned and graded and a desirable package has been selected.

(1) The appearance of the product must be attractive when offered to the public. Attractiveness is secured not only by cleaning, grading, and using the proper package, but the vegetables must be skilfully arranged. The top layer must show to advantage, but the arrangement should be pleasing down to the bottom. Appearance often may be improved by lining the package or by using a border of paper; by wrapping tomatoes, for example, with soft paper; by enclosing bunches partially or entirely in parchment paper or cellophane; by tying bunched vegetables, such as celery, asparagus, rhubarb, and the root crops, with blue or red tape, and by branding or labeling wrappers, covers, or packages.

(2) Honest packing is absolutely essential to retain satisfactory sale outlets. This means uniformity of grade throughout the package, and it prohibits deceptive "topping." Sizes, weight, and counts should be as they are represented and the packages should be full.

(3) The specimens should be placed in such a manner that they will remain securely in position until the market is reached, to avoid bruising and to retain display values.

The usual weights for packing vary in different regions and markets, often for important reasons. Eighteen-pound or heavier bushels of spinach are standard in most winter shipping regions, but 15 pounds is as much tender spring grown spinach as can be packed without crushing. In Ohio and in some adjoining regions 10 pounds of spinach or leaf lettuce are the standard pack in 24-quart baskets. Tomatoes commonly are sold in packages of 10, 20, or 30 pounds, or in 8, 12, or 16-quart containers. Many special packs are popular locally.

Standard weights to the bushel, as specified by many states, are subject to variation. They are utilized mainly in selling by the bushel as computed from the weight when delivery is made in bulk. When vegetables are packed in the customary manner in baskets or crates, the dimensions and volume of which must comply with legally established United States Standards, they are generally sold by the package rather than on a weight basis. However, at least fairly uniform weight of packages is nearly always an advantage. It inspires confidence in the purchaser and he is enabled to calculate resale prices on a definite basis.

The standard package weights of certain containers employed by the United States Department of Agriculture in compiling statistics corresponds closely with ordinary commercial usage. They

are presented here for information only and may or may not be the legal weights, which in some cases have been established.

Bushel—	18 pounds	for kale, spinach
	25 pounds	for peppers
	30 pounds	for snapbeans, peas
	32 pounds	for lima beans
	33 pounds	for egg plant
	48 pounds	for cucumbers
	50 pounds	for carrots (topped)
	52 pounds	for beets (topped)
	53 pounds	for tomatoes
	60 pounds	for potatoes
Crates—	24 pounds	for asparagus
	39 pounds	for cauliflower, N. Y. 1½ bu. crate
	60 pounds	for cantaloupe, standard crate
	75 pounds	for lettuce (head) western crate
	90 pounds	for celery, 2-3 crate
Sacks—	100 pounds	for potatoes

Marking packages.—In some states and for interstate shipment certain markings may be required, and the grower should ascertain these requirements. In fact several states require that all vegetables received from other states in either open or closed packages must be graded in accordance with United States standard grades and also must be marked or labeled with the grade name and the grower's or packer's name and address. In any event, marking the package with the grower's name, address, and trademark, and the weight or count of the contents is effective in gaining recognition in the markets and in securing top prices.

TRANSPORTATION

After harvesting and packing, transportation is the next step in marketing and a very important one. Speedy delivery, minimum damage and deterioration en route, and low cost are essential.

Motor trucks, for the delivery of vegetables, are indispensable except in locations very close to the point of sale or shipment. Whereas 15 or 20 miles were extremely long hauls with horses, the motor truck enables the same grower to market within a normal radius of 50 to 150 miles at no greater transportation cost. In the case of valuable vegetables, very large loads, or unusually attractive prices it may be advantageous to transport vegetables several hundred miles by truck. The ability to reach any market within 200 or more miles in eight or ten hours enables the grower to deliver his products before midnight of the day they are harvested and at a destination chosen on the basis of the morning market report.

The capacity of the chassis and the type of truck body selected should be appropriate for the size and nature of the average load. In one case a platform or stake body, providing large loading space and maximum ventilation, may be needed. In another, a closed body may be preferable to protect the load from heat, cold or drying wind. The trucks nominally rated at 1½ tons capacity have generally proved most economical and fully satisfactory, when equipped with suitable tires and springs, for loads to about 4 tons. Typical costs per ton mile are four to six cents. Actual cost may be lower or higher, varying mainly with total annual mileage and average size of loads.

An important possibility is the use of ice abroad the truck, around or among the packages, according to the nature of the contents. Several tarpaulins tightly roped as a cover and corrugated cardboard or fibre building board as a lining for the truck bed provide effective insulation for ordinary hauls. Refrigerated trucks are restricted by cost to steady service in transporting valuable produce.

Transportation by rail.—Enormous quantities of vegetables are transported by railways, shipments being made by freight and express. It is common to find solid trains of a single vegetable moving toward the great centers of population. By wiring the carrier's agent at a pre-arranged diversion point, the shipper may specify the destination after the car is rolling. This device permits shippers to start unsold cars toward the large markets, sell them en route on late market information, and provide quick delivery after sale.

For summer shipments the cars must be iced or well ventilated. Refrigeration is universally employed for certain vegetables, and, when the distance is very great, re-icing may be necessary to insure delivery of the vegetables in first-class condition. In the winter, cars must be properly insulated if necessary to prevent freezing of vegetables.

Correct loading of cars is imperative to prevent shifting of the cargo in transit and its subsequent arrival with many packages crushed or broken and the contents spilled or damaged. Details of correct loading vary with size and type of packages. Information on loading, refrigerator service, and schedules may be secured upon application to railway agents.

Number of packages to the carload varies with such factors as size and weight of the packages, ventilation and top-icing requirements, and length of time en route. The usual range of loadings with bushel baskets, bushel hampers, crates of about a bushel capacity, and 50-pound sacks is approximately 400 to 600 packages to the car. The number of western type lettuce crates—also used extensively for other vegetables—and standard cantaloupe crates is generally about 300 to 350. Barrels, barrel-size crates, and 100-

pound sacks are generally loaded at the rate of 200 to 300 packages to a car. Among the smaller packages typical examples are about 600 western type lug boxes or 1,000 12-quart climax baskets of tomatoes, 1,200 25-pound or 2,500 10-pound bags of onions, 650 to 850 flat crates of cantaloupes, 600 pyramid crates of asparagus, and 400 to 600 crates of cauliflower. Loadings of watermelons are discussed on page 459. Cabbage, roots or potatoes sometimes are loaded in bulk about 24,000 pounds to the car.

Transportation by water is employed to a considerable extent among growers who are situated on the large bays and sounds of the southern seaboard states. Delivery may be direct to city wharves, or to steamers which carry the vegetables to distant markets. Refrigeration en route is provided, when necessary, either by mechanical equipment or by ice.

SELLING

The grower's responsibility.—Too often the grower acts upon the assumption that if he produces a large crop of the best quality and places it on the market in the usual style, whatever that may be, he has done all in his power. The problems of marketing, however, affect profits as directly as the difficulties of production, and they may be fully as intricate.

The ultimate aim should be to serve the consumer. This is the fundamental principle involved. Unquestionably the demand for peas, snap beans, sweet corn, muskmelons, and other vegetables of variable quality could be increased greatly if consumers invariably found the quality surprisingly good. Even potatoes vary greatly in quality and poor ones divert demand to competing foods.

Sales outlets.—The possibilities to be considered in planning the marketing program may include many types of outlets. The best method is determined by distance to market, volume of production, nature of the crops, existence of facilities or services, and the ability and taste of the grower for selling.

Enumeration of the more important types of buyers and outlets follows: commission merchants, jobbers or wholesalers, chain stores, retail store routes, hotel and restaurant routes, country dealers who ship, merchant truckers, hucksters, farmers' markets of many descriptions, terminal auctions, country auctions, canneries, freezing plants, consumers' markets, and roadside markets. The order of enumeration is without significance. Any one of these may be the sole and most advantageous method of marketing for a certain grower or community yet absolutely without value for others.

Many growers find it expedient to sell through two or more types of outlets, to secure sale from one if the other fails in demand and to keep buyers in line for various grades or kinds of vegetables.

Courtesy Northern Ohio Food Terminal and The Cavalier-Gulling-Wilson Co.

FIG. 71.—Centralized market facilities at Cleveland. Growers market sheds (at lower left), team tracks, auction building, cold storage, and the four unit buildings of the market district. Wide driveways with direct access to through streets avert congestion, accelerate distribution.

The advantages of the most important types can be discussed briefly.

Selling by consignment to city commission merchants permits operation on the largest scale. Solid truck loads or carloads are delivered to one house. The same house should be employed regularly in a given city. Before making a consignment it is important, of course, to investigate the sales specialties and financial responsibility of dealers. Many of the most successful growers sell entirely on commission and acclaim the service, honesty, and integrity of their representatives. Shipments are regulated in accordance with latest market information, usually secured by telephone or telegraph directly from the receiver.

Selling outright to wholesalers and to chain store warehouses often provides satisfactory large-scale movement.

Wholesale selling at the farm or track has become of great importance in many sections. Purchasers may be country shippers, agents for wholesalers or chain stores, merchant truckers, retail stores, or hucksters. Where country buying is an established practice and a number of purchasers are in the field, the selling practically amounts to an auction without an auctioneer, provided the grower keeps himself well informed, alert to the market situation and his own interest.

Auction markets in the country, usually under the control of growers, have been very successful in cases where it has been possible to secure sufficient concentration of offerings and of buyers. Terminal auctions are operated most commonly as an auxiliary service by transportation or cold storage agencies.

Farmers' wholesale markets are of great importance in the distribution of vegetables in many cities. Shed or other facilities may be provided by municipalities, by market house companies, or by growers' organizations. The gardener places his truck in the market where grocers and hucksters gather to secure their supplies. This usually is much better than driving from store to store to make sales.

Retail store and hotel routes.—Selling to retailers or restaurateurs by delivery at regular and frequent intervals is extensive among growers with medium acreages. Large volumes may be moved when continuous supplies and regular deliveries are maintained. The cost of marketing is less than when retailing, and prices average higher than in consignment and large lot selling. It is imperative to make deliveries on schedule and early in the day.

Selling to consumers.—When a limited area is cultivated it is often an advantage to sell direct to the consumer, because the gross receipts will be larger than when selling at wholesale. The most common direct methods are to sell from house to house or in a city

retail market. When either of these plans is used, it is mainly a question whether the time of man and vehicle when thus engaged is worth more than when employed at home in giving the crops better care or in cultivating a larger area. It is possible to minimize profits by spending too much time seeking buyers of small lots.

When selling is from house to house it is essential that the goods be first-class in every particular to build up a regular trade. To retain customers it is important also to make trips at regular intervals and to offer a variety and succession of vegetables over as long a season as possible.

Courtesy Northern Ohio Food Terminal and The Cavalier-Gulling-Wilson Co.

FIG. 72.—Well arranged growers' market adjoining the railroad terminal yards and market district in Cleveland. *See Fig. 71.*

Many cities have retail markets where farmers come and sell directly to the consumers. When this method is followed the grower should always occupy the same place so that regular customers will know just where to find him. An assortment of vegetables may be important or it may be an advantage to make a speciality of a few which are grown to a high degree of perfection. The gardener will soon become well known for these particular crops.

Another important means of selling directly to consumers is the roadside market.

Roadside marketing and retail selling at the packing house may be developed into an important outlet if the farm is located on a busy highway or in a populous locality. Structures range from

simple tables in the shade to tents, sheds, and substantial buildings. The number of customers may be increased by always maintaining neat, tasteful surroundings and attractive displays of fresh vegetables. Plainly lettered road signs are effective aids. But the biggest factor in establishing a clientele of repeating customers is invariably to sell vegetables of freshness and goodness rarely procurable in the city, "the good things of the garden at their best."

Fig. 73.—At the roadside market, wide driveways invite customers.

Operation of a large roadside market can be managed without annoyance by means of strict organization to cover the many details. In the farm office a large wall calendar shows the working hours of salespersons during each day of the week. Posted on the market, in the packinghouse, and at the telephone are lists of crops available with the prices of each. The experienced man or woman who happens to be in charge is responsible for checking stock on hand against the list and ordering replenishments from the field. Thus displays are kept complete. The same person also is responsible for keeping the display attractive and the black boards up-to-the-minute.

Advertising.—The simplest and most inexpensive form of advertising is to mark packages with the grower's name or brand. By this means the demand for a grower's products usually may be

increased and an additional dime or more for a package eventually can be secured.

There are many other practical opportunities for advertising on the part of the individual grower. Announcements of crops and prices may be sent periodically by mail to a list of prospective customers, whether wholesalers, retailers, or consumers. In the smaller cities and towns it often pays well to advertise regularly in the local newspapers.

The possibilities for profit from more extensive advertising campaigns deserve study by large producers and organizations.

Sales management is a profession in itself. Most vegetable growers, however, perforce must manage their own marketing, and each will do well to examine his own methods for inadequacies, and for possibilities of improvement or innovation. Are federal or commercial market reports received and studied daily? Are the wires used freely to secure last-minute information and to keep in close contact with buyers? Are prospective customers notified in advance when shipments will begin, peak movements occur, or declines take place? Are complaints not only adjusted but is the customer solicited to make sure the pack and service are pleasing? Are his suggestions and counsel sought as to how competition may be met most effectively? Finally, has a sense of friendliness and mutual confidence been established? There is no reason why skilful pro-

FIG. 74.—Bountiful displays of fresh products, and helpful salespeople, stimulate substantial purchasing.

ducers should not meet with equal success in the disposition of their crops, but they must study and master the details of marketing just as they have studied and mastered every point that counts for successful production. If the grower ships or does not make deliveries himself, he occasionally should follow the carload or accompany his truck to check his pack on arrival and compare it with competing offerings. He may utilize inspectors of the U. S. Bureau of Markets to secure unbiased reports on condition of consignments at the destination.

Statistics of production and prices are found on pages 524 to 530.

COOPERATIVE SELLING

Cooperative versus commercial sales agencies.—A number of large and small cooperative marketing organizations have been operating successfully for many years. On the other hand, equal or greater numbers have failed to survive, and for many different reasons.

In considering such matters it is wise to remember that it costs approximately as much to perform a certain service, in this case the selling and distribution of vegetables, no matter by whom or what agency it is done. Essential activities of soliciting business, keeping books, collecting money, adjusting claims, providing quarters, are inescapable. If the cooperative organization can be managed to do the job better or more economically than the commercial distributor it is certain to succeed and grow strong. Otherwise it is destined to fall before the more efficient service.

Advantages of cooperative marketing.—Successful cooperative organizations relieve the grower of a heavy burden and strain in the selling of his produce, although the same is true with a dealer or broker of the highest type. All his time and energy may then be devoted to the work of production and the preparation of crops for market. In consequence his output may be increased. Seeds of one tested strain are planted by all, so that a great volume of a uniform product will be available for marketing. Grading, packaging, packing, and branding can be standardized. More numerous and distant markets can be reached. A saving may be made in the purchase of supplies.

Management of an association should be in the hands of a board of directors who are chosen because of their extensive experience or peculiar fitness for the responsibilities devolving upon them. They employ a manager, who usually gives all of his time to the business affairs of the association. It takes a keen, shrewd, alert, tactful executive to handle the business of a large organization. He must have thorough knowledge of men (producers on the one hand and

buyers on the other), transportation companies and their methods, refrigeration, industrial conditions, cities, supply and demand, centers of production, movement of crops, and dealers in the various cities to be supplied; he must keep in daily or hourly touch with all the great markets in order to avoid gluts and to sell at highest prices.

Bonding of fiscal officers, institution of standard methods of accounting, and certified auditing of accounts are essential, sound business practices.

In some cases producers' organizations employ established commercial agencies to distribute, perhaps even pack, their vegetables.

XII

STORAGE

Usefulness of storage.—Storing usually increases the hours of labor expended on the crop; facilities often must be provided; there is always more or less shrinkage, sometimes considerable spoilage; and there may be little or no advancement in price. Except with potatoes, the inducements to store for winter sale are less attractive since improved shipping methods have made fresh southern vegetables cheaply available throughout the cold months. Many gardeners prefer to sell the fall crops directly from the field.

Nevertheless, storage is often an advantage and sometimes a necessity. It may be that sale at harvest is impossible. Again, storage of some vegetables may be useful to supply and hold a regular trade. An increasingly important form of storing is short term cold storage, a few days or weeks in summer. By this means highly perishable crops, such as peas or lettuce, may be harvested on the day they come into prime condition and held for a favorable or regular market day, for gradual sale to regular trade, or for avoidance of market gluts.

RECOMMENDED CONDITIONS

Vegetables, even after harvest, are living plant parts which require oxygen, give off carbon dioxide and other products of respiration, and generate heat. Ripening or other changes in composition continue and the rate of activity, which varies greatly with different vegetables, increases rapidly as the temperature rises. Under favorable conditions, many vegetables may be kept for long periods without serious loss in quality. Otherwise quality soon disappears and decay begins (p. 435).

The main factors to be considered in constructing and managing storages are temperature, humidity, and ventilation. Adaptation of variety, suitable degree of maturity, freedom from disease, and care in handling are important factors in assuring good keeping.

Details of storing different vegetables are discussed with the culture of the several crops. No general rule will apply to all classes of vegetables.

Temperatures as close to 32 degrees F. as can be maintained without freezing are generally recommended for the storage of most vegetables. Temperatures between 33 and 35 degrees F. usually prove fully satisfactory, but temperatures above 35 degrees F. are

RECOMMENDED STORAGE CONDITIONS AND APPROXIMATE MAXIMUM STORAGE PERIOD FOR VEGETABLES

Vegetable	Storage[1] Temperature °F	Storage[2] Temperature °F	Relative[1] Humidity %	Relative[2] Humidity %	Maximum[1] storage period	Approximate[2] storage life	Water content %	Average freezing point °F
Asparagus	32	32	95–98	85–90	1 week	3–4 weeks	93.0	29.8
Beans, snap	40	32–40	90–98	85–90	12 days	3–4 weeks	88.9	29.7
Beans, lima	32	32	90–95	85–90	2–3 weeks	3–4 weeks	66.5	
Beets, topped	32–40	32–35	90–95	95–98	4–5 months	3–6 months	87.6	26.9
Beets, bunch		32		90–95		7–10 days		
Broccoli, sprouting	32	32	95–98	85–90	10 days	10–12 days	89.9	29.2
Brussels sprouts	32		95–98		2 months			
Cabbage	32–40	32	90–98	90–95	5 months	3–4 months	92.4	31.2
Carrots, topped	32–40	32	90–95	95–98	6 months	2–4 months	88.2	29.6
Carrots, bunch	—	32		90–95		7–10 days		
Cauliflower	32	32	90–98	85–90	30–40 days	2–3 weeks	91.7	30.1
Celery	32	31–32	90–98	95–98	3–5 months	2–4 months	93.7	29.7
Corn, sweet	32	31–32	90–98	85–90	3–4 weeks	1–4 weeks	73.9	29.0
Cucumbers	32–40	45–50	95–98	85–90	4–5 weeks	6–8 days	96.1	30.5
Eggplant	32	45–50	90–95	85–90	3–4 weeks	10 days	92.7	30.4
Endive		32		90–95		2–3 weeks	93.3	30.9
Garlic		32		70–75		5–6 months	74.2	25.4
Horseradish		32		90–95		4–6 months	73.4	26.4
Kale	32		95–98		1 month			
Leeks		32		85–90		1–3 months	88.2	29.2
Lettuce	32	32	95–98	90–95	3–4 weeks	2–3 weeks	94.8	31.2
Melons,								
Muskmelons, immature	50		80–90		2 weeks			
Muskmelons, mature	32		80–90		1 month			
Muskmelons		50–55		80–85		1–3 weeks	92.8	25.5
Watermelons		35–40		80–85		1–3 weeks	92.1	28.8
Honey Dew—Honey Ball		40–50		80–85		3–4 weeks		28.8
Casaba and Persian		35–40		80–85		4–6 weeks		
Onions and onion sets	31–32	32 –	80–95	70–75	5 months	5–6 months	87.5	30.1
Parsnips	32	32–34	90–95	90–95	5 months	2–4 months	78.6	28.9
Peas, green	32	32 –	95–98	85–90	2 weeks	1–3 weeks	74.3	30.0
Peppers, sweet	32	32 –	95–98	85–90	40 days	4–6 weeks	92.4	30.1
Peppers, Chili (dry)		32–50		70–75		5–9 months		
Potatoes		36–60		85–90		3–5 months	77.8	28.9
Pumpkins	40	55–60	50–70	70–75	2–3 months	2–6 months	90.5	30.2
Rhubarb		32 –		90–95		2–3 weeks	94.9	28.4
Rutabagas	32–40	–	90–95		3–4 months			
Squash	40	55–60	50–70	70–75	5 months	2–6 months	90.4	29.3
Sweet Potatoes		50–55		80–90		4–6 months	68.5	28.4
Tomatoes, ripe	40	50–55	95–98	80–85	10 days	7–10 days	94.1	30.4
Tomatoes, green ripe	50–60	–	95–98		1 month			
Tomatoes, mature green		55–70		80–85		1–6 weeks	94.7	30.4
Turnips, (including rutabagas)		32		95–98		2–4 months	90.9	30.5

[1] H. Platenius in Cornell Bulletin 602. [2] D. H. Rose in U. S. D. A. Circular 278.
Compiled by Donald Comin, 1937 Proceedings Ohio Vegetable Growers' Association.

likely to result in rapid deterioration. Short-term storage of many vegetables, however, is possible at about 40 degrees F., and this is nearly ideal for snap beans, cucumbers, melons, and ripe tomatoes. Temperatures of 50 degrees or slightly more are most favorable for sweet potatoes and mature green tomatoes. Temperatures of 36 to 40 degrees are considered ideal for potatoes. (See the table of recommended storage conditions, p. 205.)

Humidity.—Regulation of humidity is an important factor. A few vegetables, onions, sweet potatoes, squashes, and pumpkins, must be kept relatively dry to prevent decay. But root crops, cole crops, in fact, most vegetables, require relatively high humidity, approximately 90 to 95 per cent, to preserve their plumpness and succulence and to avoid shrinkage. On the other hand, excessive moisture engenders decay; hence, humidity should never be permitted to rise so high that moisture will condense upon the vegetables or drip from the ceiling. Excessive humidity may be reduced by increasing ventilation when temperatures permit, or at other times by exposure of calcium chloride to absorb the excess moisture. Too low humidity may be corrected by sprinkling the floor with water. Refer to the table for additional detail.

Ventilation.—Air is necessary to supply oxygen and to remove carbon dioxide and other respiration products, moisture, and heat liberated by the vegetables. The amount of ventilation will be determined by the type of storage and class of crops. Excessive ventilation results in wilting and shrinking. Inadequate ventilation is characterized, for example, by heating and decay of leafy crops, early sprouting of root crops, and development of blackheart of potatoes. In common storage, regulation of the air supply is the principal means of controlling both temperature and humidity. In cold storage, where the temperature can be kept very close to 32 degrees, relatively little ventilation is required.

Condition of the crop.—Many vegetables possess better keeping qualities when placed in storage just before they have fully matured. This is particularly true of the cole and salad crops. Onions keep better when harvested promptly at maturity. Potatoes and squashes should be fully mature. Overmaturity is undesirable in root crops, as they are likely to be even more woody when taken out of storage. Planting dates of vegetables which are to be stored should be regulated carefully.

Losses in storage often are due to diseases which have developed in the field. When such infections are known to exist and to be a common source of trouble in storage, the safer course is to dispose of the crop without attempting to preserve it for later marketing. Unusual care should be exercised to control diseases, as well as

insects which may open the way for decay, on crops that are intended for storage.

Too much care cannot be taken in handling the crops to be stored. Every bruise invites decay and reduces the average grade of the product. Great losses may occur from decay in storage when rough handling or hauling causes extensive breaking of the surfaces and bruising. In some cases vehicles with springs or pneumatic tires are almost necessary. Straw and hay are commonly used in loading squashes and melons.

In planting vegetables for storage it is important to select varieties that are well suited to the purpose, as indicated in the variety descriptions contained in the catalogues of reliable seedsmen.

TYPES OF STORAGES

The three main types of storages are earth or pit storage, common or air cooled storage, and refrigerated or cold storage. Many forms of these are in successful use, and differ with the crops grown, climatic conditions, and desired length of storage period. Facilities that are far from ideal are often used quite successfully for emergency, short-time storage.

The house cellar.—The cellar of the residence is often used to store vegetables. As a rule it provides unsatisfactory conditions, especially if it contains a furnace, because the air is then too warm and dry. These difficulties may be overcome to some extent by separating the storage room with suitable walls, and covering the pipes with asbestos. Ample ventilation must be possible, and the root crops may be covered with a few inches of moist soil or sand to prevent withering. Shelves in the drier parts of the room will be desirable for sweet potatoes, squashes, and onions. Onions should be in slatted crates, placed so that there will be free circulation of air on all sides and beneath. Cabbage may be wrapped in paper to delay wilting.

Pits, mounds, and trenches of suitable types are used extensively in storing roots, cabbage, celery and white potatoes. However, growers store less by these means than formerly because the vegetables can not compete in attractiveness with fresh southern produce, or with vegetables from refrigerated storages. An advantage of pits, mounds, and trenches is the fact that no capital is invested in storage facilities. But labor of storing is great and removal of produce often is difficult and unpleasant on account of frozen condition of the earth covering or of muddy surroundings. Potatoes especially, if warm with field heat, should be allowed to cool in any convenient manner before piling in the pit.

A cross section of a popular and satisfactory form of pit that is well adapted to root crops, potatoes, and even cabbage is shown in Figure 75. On exceptionally well drained soil some growers prefer to make the pit deeper. On wet land the vegetables may be placed on top of the soil and covered by mounding. In preparing the pit shown, much of the soil may be thrown out by making two rounds with a common plow, leaving a "dead furrow" in the middle. The remaining loose soil is shoveled out to make a flat trench about 3½ feet wide and 6 to 10 inches deep. If the width is greater, the vegetables in the bottom center of the pile are likely to heat. In filling, the vegetables are piled as high as possible in the form of an A-shaped ridge. Straw or other litter to make a layer of about four

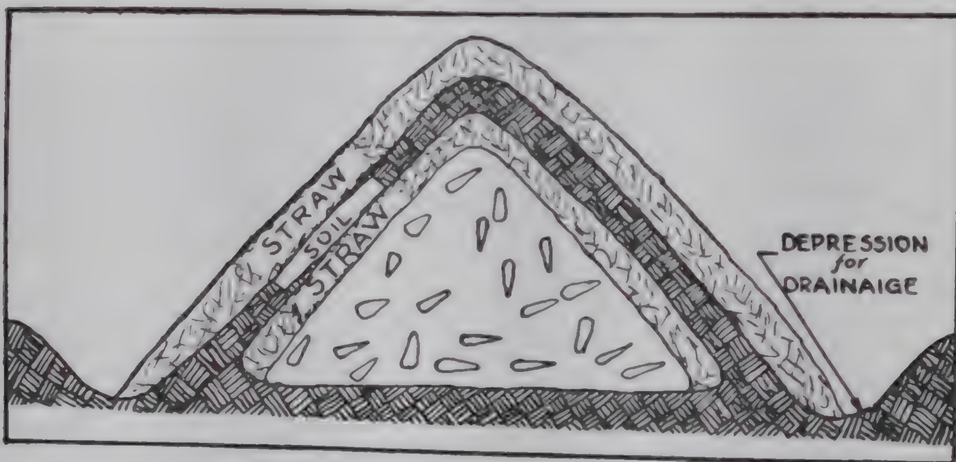


FIG. 75.—Common storage pit used to keep root vegetables and potatoes. On well drained land excellent results are usually secured.

inches when compacted and an equal or greater thickness of earth are applied at once. An additional layer of straw or coarse manure and enough earth to hold it in place should be added, if very low temperatures are to be expected, but not before continued cold weather is at hand. Tile or board ventilator flues, which often are placed at the ridge, are unnecessary when the cross-section of the pile is small, as suggested, and serve only to admit rain and rodents. When the work is well done, root crops and white potatoes may be kept until early spring with little risk. Trenching celery and burying cabbage are similar methods which are described with the culture of those crops (pp. 228, 264).

Some gardeners often find it convenient to bury a barrel of vegetables, or to make small, round mounds with a large tile or board tube at one side to permit removal of a few vegetables at a time, and keep the opening closed with straw or old fabrics.

Coldframes may be used to advantage in storing some vegetables. The drainage around them must be thorough, and mats, shutters, or boards must be provided to cover them. An excellent plan is to cover the sash with boards after the frames have been filled, and then to bank the outside of the frames with soil or manure. As the weather becomes severe, straw may be placed over the frames and covered with shutters or boards. Celery, cabbage, cauliflower, and root crops are often stored by this means.

Bank storage cellars are permanent, underground or partly underground storages which are particularly suitable for the storage of white potatoes and root crops. They are useful to a limited extent for other vegetables. When they are properly built, little attention is required to maintain even, cool temperatures and suitable humidity.

Storage cellars may be constructed by excavating in a convenient hill, or by covering a partly or entirely above-ground structure with 2 or 3 feet of earth as insulation. An earth floor aids in the maintenance of proper humidity and is preferable to concrete. Ventilation is provided to best advantage by large doors, big enough to drive through if the storage is of some size. If the cellar is long, one or more ventilating shafts of large diameter should be placed in the ceiling, unless there are doors at both ends. Small tiles are ineffective ventilators; they do not transmit enough air.

In operating the storage during the fall, the doors and ventilators are closed when the outside air is warm and opened at night and on cold days. Later ventilation must be restricted to prevent freezing, although the earth of the floor and around the walls and ceiling exerts a remarkably tempering effect and permits more ventilation in cold weather than the inexperienced operator would expect.

Small bank storages often are built of locust or other durable woods. It is more satisfactory to construct them with stone or concrete walls and reenforced concrete roofs. Cement manufacturers will supply information on plans and details of construction.

Common storage houses are above-ground structures which are not equipped with means of refrigeration. They are a necessity where low humidity is required and are used principally for the storage of onions, sweet potatoes, and, to a limited extent, for squashes and cabbage. For sweet potatoes and squashes some method of heating usually is provided to assist in the curing process and to maintain suitable temperatures in cold weather. Insulation of the walls and ceilings can be accomplished by the use of various materials but must be sufficient to prevent freezing during the coldest weather (pp. 318, 425).

Details of construction vary greatly for different crops and conditions. The grower without experience with common storage who

contemplates construction should communicate with his state agricultural college and inspect successful houses.

Central storage houses, the managers of which may buy, store, and sell, or perhaps rent space to growers, are a practical economical development of many shipping points.

Frick Company, Inc.

FIG. 76.—Celery in cold storage. Spaces between the crates promote more uniform cooling. Strips of 2 x 4-inch lumber are placed between the tiers.

Cold storage, in which temperatures are reduced by refrigeration, is essential for even short-term storage of lettuce and spinach and is ideal for celery, cabbage, cauliflower, and many other vegetables. The outstanding advantage of cold storage is the ability to cool crops to the desired storage temperature within a few hours, regardless of the season or the outside temperatures. With the best construction and management, temperature variations are held within a range of one degree and humidity can be regulated. Serious deterioration can be eliminated unless the storage period is abnormally long for the crop.

In this connection it should be noted that the most common cause of spoilage in cold storage is the failure to pile the packages with adequate provision for the circulation of air. Sweating, heat-

ing, and decay are certain to follow. It is a serious temptation to crowd the storage to accommodate more packages. Many growers have found that a larger amount of merchantable vegetables can be taken out of the storage if a smaller quantity is put in.

Cold storage probably is used most largely by vegetable growers in the form of rented space, for which compensation usually is made at a certain rate a month for each package, or for the season of storage. This is a popular arrangement, where space is available, for cold storages are expensive to build and usually must be operated much of the year to prove profitable. Commercial cold storage space is available in the larger cities and at many important centers for shipping. Celery is stored extensively under such arrangements.

On occasion some growers ship produce to cold storage warehouses in the larger cities. There the vegetables are held for a more favorable market, rather than attempting less satisfactory methods of storage on the farm. Some growers, however, have built sizeable cold storages and consider them a profitable investment for certain special crops. Many others have smaller rooms where a truck-load or more can be placed for pre-cooling, for later orders, or for better markets. The counsel of competent refrigerating engineers should be secured in planning the construction of cold storage facilities.

XIII

COLE CROPS

The cole crops belong to the genus Brassica, are hardy, grow best in cool, moist seasons, have more or less similar cultural requirements, and generally are subject to attack by the same insects and diseases. Among the cole crops not discussed in this chapter are rutabaga, which is considered with root crops, and kale and collards which are grouped with potherbs and greens. All probably are descended from the same source, or one from the other, are unlike in vegetative character but similar in floral characters, and cross readily.

Cabbage is by far the most important of the cole crops. Its culture, including control of insects and diseases, is discussed at some length. The same general practices apply to the production of other coles; hence, these crops are discussed briefly and principally with respect to their special requirements.

CABBAGE *(Brassica oleracea, var. capitata)*

History.—In its leafy wild state cabbage is found on the sea coasts of western and southern Europe. It has been known from earliest antiquity and probably was in general use previous to the Aryan invasions, in 2000 to 2500 B.C. Several types were cultivated in ancient Greece and Rome. No doubt, it was used in the wild state before there were cultivated forms.

Plant characteristics.—The wild cabbage plant is herbaceous, usually perennial and sometimes biennial, attaining a height of 2 to 3 feet. Cabbage is a biennial plant, but it is cultivated as an annual crop. There is great variation among cultivated types. The heads may be large or small, flat, flattened, globular or elongated, pointed acutely or obtusely, horizontal section round or angular, soft to very hard. The head leaves may reach or pass beyond the center; may be drawn or folded tightly or loosely, thick or thin, crisp or tough, well blanched or poorly blanched, sweet or bitter, flavor good or poor. The core may be large or small, long or short. Nearly all commercial varieties are more or less round, often slightly flattened, with tightly folded leaves.

Climatic adaptations.—It is well known that cabbage thrives best in a cool, moist climate. For this reason its summer culture is confined largely to northern districts. When grown in the South,

outside the mountain areas, advantage is taken of the cool months of late winter or spring.

The Danish types, which are most limited in soil and climatic adaptation, are grown successfully south of Pennsylvania only at high altitudes.

New York and Wisconsin are first and second, respectively, and by far the leading states in production of late cabbage. Pennsylvania is third, and many other northern states produce important acreages. The Gulf states, the eastern seaboard regions, and the Mississippi and tributary valleys produce great quantities of early cabbage.

Bureau of Plant Industry, U. S. Department of Agriculture.

FIG. 77.—Wild cabbage from which cultivated forms of *Brassica oleracea* are supposed to have arisen.

Soils.—Successful crops of cabbage are grown on a great variety of soil types, the enterprise being developed to large proportions on soils ranging from light sand to heavy clays. A fertile soil, well supplied with organic matter and retentive of moisture, although well drained, is desirable. Sandy loams are preferred for the early crop, but friable heavier soils are very satisfactory. Although good late crops may be grown on fertile sandy loams that are well supplied with moisture, the largest crops of late cabbage usually are grown on silt or clay loams, well enriched with leguminous sods or stable manure. Late cabbage is grown successfully on muck soils.

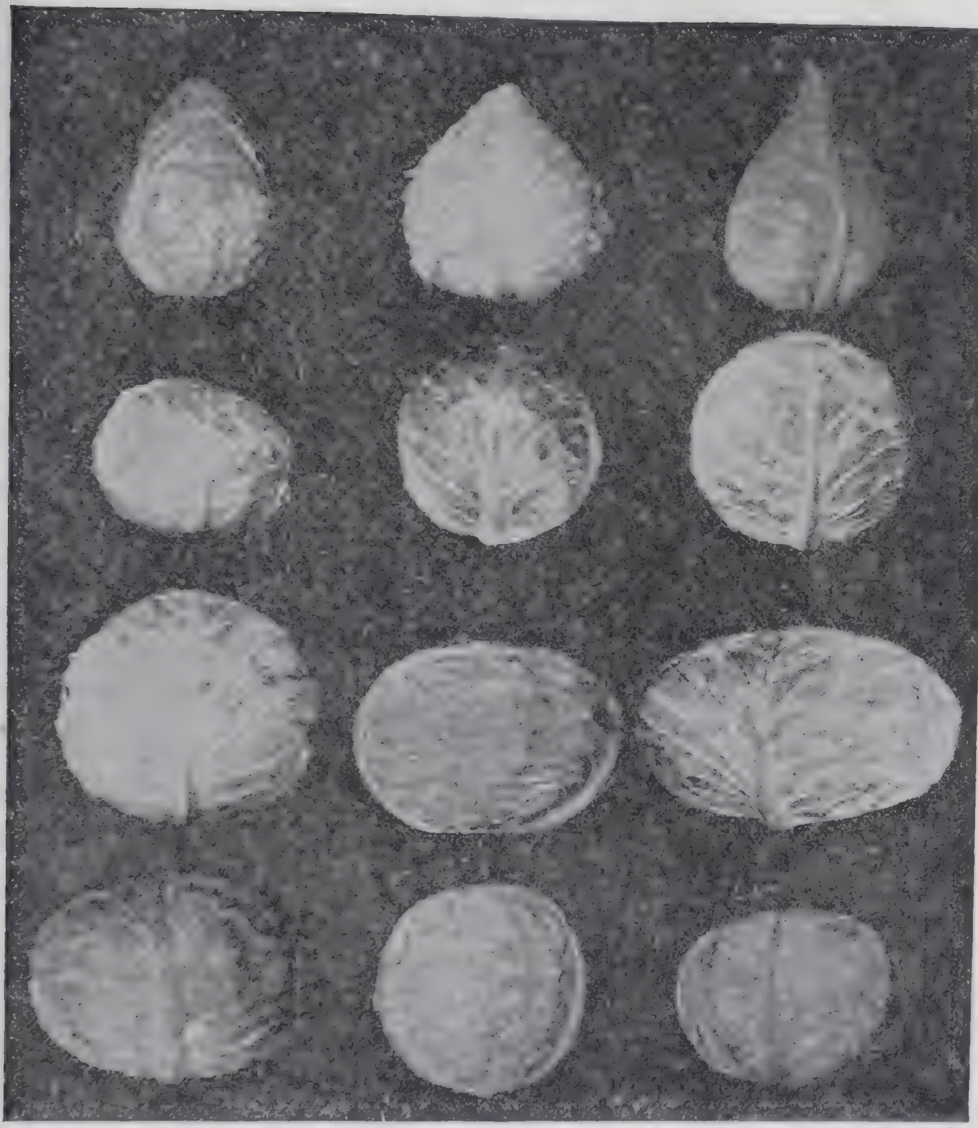
Classification of varieties.—A system of classification suggested by Allen in 1901 is the basis for the groupings that have

been used most generally. The Alpha and Volga groups may be considered obsolete and they have been omitted. The groups are indicated by the names of well-known varieties or types. Notations of typical form, season, commercial importance, and principal varieties have been included:

1. Wakefield and Winningstadt group:
   Pointed or conical. Early and intermediate.
   Locally important.
   Early Jersey Wakefield, Charleston Wakefield, Winningstadt.
2. Copenhagen Market group:
   Globular. Early and intermediate.
   Very important.
   Golden Acre, Copenhagen Market, Large Late Copenhagen, Midseason Market, Enkhuizen Glory.
3. Flat Dutch or Drumhead group:
   Flattened heads. Second early to late.
   Important.
   All Head Early, Succession, All Seasons, Sure Crop, Premium Late Flat Dutch.
4. Savoy group:
   Flat or round. Crinkled leaves. Early, intermediate and late.
   For special demand.
   Drumhead Savoy, Improved American Savoy.
5. Danish Ballhead group:
   Globular to slightly flattened. Late. Long keeping.
   Very important for fall sales and winter storage.
   Danish Ballhead, Hollander.
6. Red Cabbage group:
   Various forms. Intermediate and late.
   For special demand.
   Mammoth Rock Red.

A classification proposed in 1934 by Morrison, Drewes, and Coulter (Special Bulletin No. 249, Michigan Agricultural Experiment Station) is based on the differences in earliness of development, and the shape, size, color, and texture of the head. To quote: "These are differences recognized generally by the trade as being the most important not only in distinguishing between different kinds but in determining their value for specific purposes. . . . Only the more important commercial varieties are included, those of greatest commercial importance being indicated by italic type.

"It is not implied that perfection has been reached in these varieties or that others are not entitled to consideration. There is still ample opportunity for the breeder to exercise his skill. However, the varieties that are included have proven very satisfactory and probably constitute upwards of 90 per cent of the cabbage grown in the United States. Those with a superscript 'r,' thus Jersey Queen [r], are valuable particularly because of their resistance



Ferry-Morse Seed Co.

FIG. 78.—Typical heads of well known varieties of cabbage.

Upper row: Early Jersey Wakefield; Charleston or Large Wakefield; Early Winningstadt.

Second row: Early Dwarf Dutch; Copenhagen Market; Midseason Market.

Third row: Glory of Enkhuizen; Allhead Early; Succession.

Lower row: All Seasons; Ferry's Hollander; Danish Ballhead.

to the destructive 'yellows' disease. We have attempted to list roughly in order of earliness the varieties in each subdivision.

"EARLY
White
Globular: GOLDEN ACRE
COPENHAGEN MARKET
Flat or Drumhead: Early Spring

Pointed or Conical: EARLY JERSEY WAKEFIELD
Jersey Queen[r]

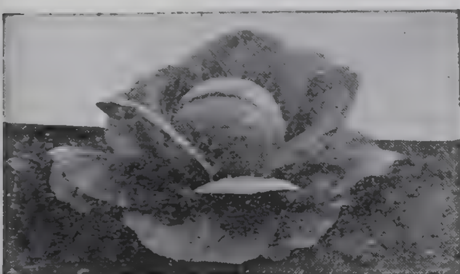
"INTERMEDIATE IN SEASON
White
Globular: Round Dutch
Marion Market[r]
Midseason Market
GLORY OF ENKHUIZEN
Globe[r]
Flat or Drumhead: Henderson's Early Summer.
ALL HEAD EARLY
All Head Select[r]
Succession
Pointed or Conical: CHARLESTON or LARGE WAKEFIELD
Early Winningstadt
Savoy
Globular: Early Dwarf Ulm
Red
Globular: Earliest Round Red

"LATE
White
Globular: HOLLANDER
Danish Ballhead
Penn State Ballhead
Wisconsin Hollander[r]
Flat or Drumhead: ALL SEASONS
Surehead
Wisconsin All Seasons[r]
PREMIUM LATE FLAT DUTCH
Savoy
Flat or Drumhead: IMPROVED AMERICAN SAVOY
Red
Globular: ROUND RED DUTCH
Red Hollander[r]
Flat or Drumhead: MAMMOTH ROCK RED

Early varieties.—The pointed varieties of the *Wakefield* and *Winningstadt* group have been superseded almost entirely by equally early, globular, higher-yielding varieties in the Copenhagen Market group. The Wakefield varieties, however, are planted extensively in the fall for the early spring crop along the coast from Norfolk southward. Under the same conditions of long exposure to cold weather most Copenhagen Market varieties produce an excessively large percentage of premature seed stalks. The quality of *Jersey Wakefield* is considered unusually high. *Charleston Wakefield* is a valuable variety to follow Jersey Wakefield when a pointed cabbage is wanted. It is 7 to 10 days later, averages about a third larger and is of good quality. Winningstadt is still later in season, quite small, and very firm.

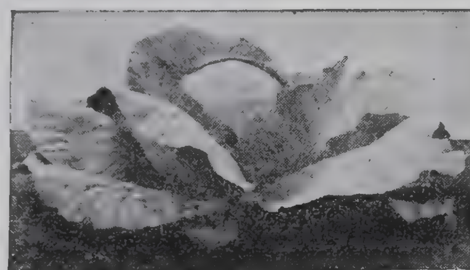
Golden Acre may be described as an early type of *Copenhagen Market*. The earliest, well-bred strains of both mature in 63 to 70

days under favorable conditions. The usual strains of Copenhagen Market are a week to 10 days later than the best Golden Acre. The heads are small to medium, 3 to 5 pounds, globular, or very slightly flattened. Outside leaves are few and short in the earliest strains. Golden Acre and Copenhagen Market are by far the most important varieties of early cabbage. Yellow resistant strains, such as *Early Detroit*, are available. The so-called *Large Late Copenhagen Market* selections mature with the intermediate varieties and are used principally for late summer and fall production, especially for kraut.



Ferry-Morse Seed Co.

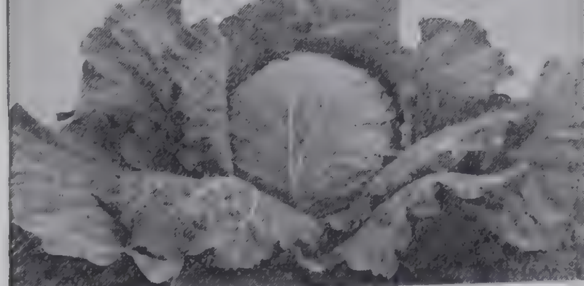
FIG. 79.—Golden Acre.



Ferry-Morse Seed Co.

FIG. 80.—Copenhagen Market.

Intermediate varieties.—*Glory of Enkhuizen* is the best known and most widely planted intermediate variety and is used most extensively to succeed Copenhagen Market in spring plantings and for late summer and fall production. It is about 10 days later than standard strains of Copenhagen Market. Growth is large and vigorous; heads are nearly round, firm, and of good size and quality; will average 4 or 5 pounds under best culture. *Midseason Market* is similar, although not so well-known, and is considered by some to be the finest of its class.



Ferry-Morse Seed Co.

FIG. 81.—Glory of Enkhuizen.

Marion Market and *Globe* are yellows-resistant strains that are similar to the foregoing in type, season, and general adaptations. They are desirable for planting on yellows-infested soils.

Ferry-Morse Seed Co.

Fig. 82.—Midseason Market.

All Head Early is a desirable second early variety of flattened type, with good depth of head in proportion to diameter. With liberal spacing on fertile soils, weights average six pounds. The variety is hardy, well adapted to winter culture in the south, and is preferred by some growers for midsummer and early fall production in the North, as well as for later use in making kraut. *All Head Select* or *Wisconsin All Head* is a yellows-resistant selection. *Succession* is a very dependable, larger heading, flat variety that matures a week or ten days later than All Head Early.

Late varieties.—The short-stemmed cabbages of the Danish type, *Ballhead*, *Hollander*, *Penn State Ballhead*, and *Wisconsin Hollander*, which is yellows-resistant, are standard. Other excellent strains are available. The intermediate and tall-stemmed types

Ferry-Morse Seed Co.

Fig. 83.—Danish Ballhead.

are grown to a lesser extent. The Danish varieties as a whole are unequalled in keeping quality and are practically the only ones held for winter sales.

The group is not adapted to warm climates or very sandy soils. Timely sowing is important to secure full yields; however, crops that barely reach maturity keep much better than those which attain full development some time before they can be stored. About 100 to 110 days are required from setting the plants until heavy cuttings can be made.

In this connection it may be explained that the expression "Danish" as used in the produce trade indicates Danish Ballhead varieties of good type, whereas the term "Domestic" is applied to others, such as Enkhuizen Glory, All Seasons, and Flat Dutch, or even to loose or off-type low grades of Danish varieties.

In the flat or drumhead group standard late varieties are *All Seasons, Surehead,* and *Premium Late Flat Dutch.* All these may be planted for late use, although All Seasons is nearly intermediate in time of maturity. Surehead is slightly later, and Premium Late Flat Dutch requires practically as much time as the Danish varieties. The plants of all of them are large and spreading; weights range from 8 to 10 pounds with All Seasons to 10 or 12 pounds or more with Premium Late Flat Dutch which requires a long season and fertile soil. *Wisconsin All Seasons* is a yellows-resistant selection. The large flat types of cabbage are now unpopular in most markets but are used to a considerable extent in making kraut.

Savoy varieties are characterized by finely crinkled leaves. These cabbages thrive best during the cool weather of the fall months and are seldom produced as an early or intermediate crop. When grown under proper conditions, the flavor is considered more delicate than that of any other cabbage. The demand is limited, however, and large areas should not be planted unless there is assurance of satisfactory market. *Perfection Drumhead Savoy,* or *Improved American Savoy,* is listed under various other names and is the only variety of general commercial importance. *Benito Savoy* is especially uniform, finely savoyed, and bright green.

Red varieties should not be planted extensively without knowledge of market conditions. Red cabbage is used principally for pickling and to add color to salads. It is most popular with people of European extraction and is grown mainly as a late crop. *Mammoth Rock Red,* or *Red Drumhead,* is the principal variety.

Seed.—For many years Long Island produced the bulk of the seed of all varieties, except Danish Ballhead which was imported from Denmark. Most of the cabbage seed used today comes from Denmark; however, excellent seed of all varieties is produced in the United States. The Puget Sound district provides favorable

conditions for economical production, but cabbage seed may be pro-duced in many states. The place of production is of less importanc than the skill of the breeder and the integrity of the seedsmar Seed treatment is essential (p. 22).

Growing early plants.—There are at least four distinct meth-ods of growing early cabbage plants: (1) From Baltimore south-ward, the general practice is to sow in the open, usually in Octobei and when six to eight weeks old the plants are set in the fielc They also may be wintered in the beds, with protection if neces-sary, and shifted to the field early in the spring. Fall planting however, is more satisfactory because it produces an earlier crop (2) The common practice years ago in the North was to sow in the open early in September and transplant into cold frames th latter part of October, protecting the plants with sash during th winter. The results were satisfactory with skilful managemen but very few growers now use this method. Plants grown b method (4) start growth more quickly after setting in the fielc (3) If earliness is not an important factor, sowing may be mad in hotbeds, cold frames, or greenhouses about March 1, and th seedlings transplanted directly to the field. When this plan i adopted, the seed rows should be not less than 3½ inches apar and the plants should be thinned if necessary. (4) The plan nov almost universally practiced in the North is to sow in hotbeds o greenhouses in January or February. If a great many plants ar to be grown it is desirable to begin sowing early and to sow at in-tervals of a day or two for two or three weeks. This will make i possible to transplant without any of the seedlings becoming spindl or drawn. For details of methods see page 53. About a quarte pound of seed sown under glass should produce plants to set an acre

Growing late plants.—Glass is not required for growing lat plants. Outdoors about a half pound of seed is alloted for eacl acre of the crop. The common practice is to sow in the open, anc transplant directly to field or garden. Many failures are due t inferior plants. It is important that every possible effort be mad to have strong, stocky plants ready for the field when conditions ar favorable for setting. It is an advantage to have the plant bec near the field to be cropped, so that the plants can be shifted with-out much loss of time or drying of the roots.

Infestation by maggots will be reduced by locating the plan bed where it is exposed to the full force of prevailing winds. Specia methods of control are discussed later in this chapter (p. 232).

In selecting and preparing the seed bed, excessive fertility shoul be avoided, for very rich soils produce weak, succulent plants whic are likely to succumb under field conditions. The seed bed shoul be free from disease organisms infecting cabbage. In order to hav

nple moisture to insure germination, the soil should be plowed early . the spring and harrowed at intervals.

The time of sowing depends upon locality, exposure, variety, and urpose of the crop to be grown. For large yields in most localities f the North, sowings should be made during late April or early Iay and the plants should be set in the field about June 15. The itest maturing varieties, such as Danish Ballhead, should seldom e sown later than May 15, and earlier sowing is an advantage where he growing season is short, as in the mountain regions of Pennsyl-ania. Early sowing is important from the standpoint of yield, vhile late sowing, avoiding over-maturity, is favorable to a long eriod of storage. Some northern growers sow intermediate varieties s early as the soil can be worked to secure crops for August narketing.

Most growers use drills, making rows about 1 foot apart, thus providing ample space for tillage with hand-wheel hoes. Too heavy sowings should be avoided; they may require thinning in order to secure stocky plants. Eight to ten seeds to an inch of drill should make a satisfactory stand. If the soil is fine and moist, ½ to ¾-inch of covering will insure germination. Some successful growers prefer broadcasting rather thinly to avoid crowding of plants. When this is done the bed should be in the finest possible condition and the seeds raked in lightly with a garden rake. Weedy land is not suitable for this method. In broadcasting about 1 pound of seed is sown to 3000 square feet of plant bed.

Sowing where the plants are to mature.—The expense of transplanting is avoided and there is no checking of growth, which is incidental to this operation. On the other hand, it is more expensive to combat insects when the plants are scattered than when they are confined to a small area. The expense of tillage is increased, and the cost of thinning must be taken into account. Sowing may be a week later than when the crop is started by transplanting. When the plants are three or four weeks old they should be thinned, leaving the strongest at each place. Sowing in place is practiced to an exceedingly limited extent.

Soil preparation.—For early cabbage, fall plowing is often desirable; heavy sods especially should be plowed down in the fall for best results. The vegetable matter will then be partly decayed by planting time and of more immediate value to the crop; the soil will be filled with moisture, which should be conserved by harrowing as soon as the ground is dry enough. This tillage operation should be repeated as often as may be necessary to keep down weeds and to put the land in proper condition for planting.

Moisture is the most important factor in preparing soil for late cabbage. Many failures are due to late plowing of green manures

or of sods, followed by dry weather, which sometimes continues long after the proper time for transplanting. The only safe practice is to plow rather early in the spring, working down the land, as explained for the early crop.

Fertilization.—Cabbage is especially responsive to appropriate applications of commercial fertilizers. Neglect of the supply of organic matter, however, will lead to serious reduction of the crop in dry seasons. An abundant and constant supply of both moisture and nutrients is required for rapid growth of a heavy crop of cabbage.

One thousand to 2,000 pounds of fertilizer to the acre generally are used for the early crop, and most growers of late cabbage apply about half of these amounts. Formulae range from superphosphate alone or 4-16-4 on clover sods and well manured soils of the heavier types, to 4-12-4 or 4-10-6 on lighter soils of moderate fertility, and to 5-10-5 on poorer soils. On sandy soils and mucks, mixtures with more potash are likely to be beneficial, perhaps 4-8-8 and 4-8-12, respectively.

An application of 150 or 200 pounds of nitrate of soda to the acre or the equivalent about four weeks after planting, and the same amount when head formation begins, may increase the yield. It is not necessary to distribute this fertilizer around the plants or along the rows, but it may be broadcast as clover seed is sown. The results are often marked, especially when used on moderately fertile or poor soils before rain and after a long period of drouth.

Although applications of 10 to 25 tons of stable manure to the acre are very desirable for cabbage, experiments have shown that large and often more profitable yields can be secured by the use of commercial fertilizers alone on soils already fairly well supplied with organic matter.

Cabbage is moderately responsive to lime. Light liming for the cabbage crop frequently increases yields by securing more efficient utilization of fertilizers. If a test shows the soil to be quite acid, or if it is suspected that the club root organism is present, heavy liming may be required.

Planting distances.—The proper distance between plants depends upon the variety, purpose of the crop, fertility of the soil, whether it can be irrigated, and methods of cultivating, spraying, and harvesting. Early varieties, such as Golden Acre, may be planted 14x26 inches or even closer; Copenhagen Market, 16x28; Enkhuizen Glory, 18x28; Danish Ballhead, 18x30; Flat Dutch and other late flat-headed varieties, 24x36 inches. Close planting is conducive to the production of small heads, which often are preferred by consumers. The richer the soil the closer the plants may be set and still produce heads of marketable size. Some growers

Robson Seed Farms

FIG. 84.—Excellent crop, Copenhagen market type of cabbage, remarkably uniform and well grown.

vary the spacing in the row to suit circumstances, but always allow about 30 inches between rows so that standard gauge carts, wagons, or trucks may be used in harvesting. Yields by weight are larger when planting distances are medium rather than very close or wide. The most approved plan is to plant rather close in the row and allow liberal space between rows. Some growers prefer planting in check rows because of advantages in cultivating, and because less hoeing is required than in the usual method.

Transplanting in the field.—Moist soil and damp, cloudy weather are most favorable for transplanting in the field. The plants should not be checked more than necessary and an effort should be made to transfer them with as little injury as possible to the roots. Watering heavily the evening before planting, or early that morning, will make it possible to lift the plants with relatively little disturbance. If grown in flats, each plant may be removed with a portion of soil attached and, if carefully removed from the boxes, may be set in dry weather without watering, either at the time of transplanting or afterward unless rains are delayed a long time. It is urgent that no time be lost in getting the plants into the field when time for planting arrives. This time is variable through the North, but April 15 is not too early for most sections. If the plants have been well hardened, they will survive severe freezing in the field. Most of the late crop is set during the latter half of June.

In the South the plants usually are set in the fall on the south or the east side of ridges. Deep planting is very important for fall setting, to prevent splitting or bursting of the stems by freezing, and is often advisable in the North to reduce injury from hard frosts or winds.

Large areas generally are planted by machines. The transplanter is a valuable implement, because its work is better than that of most laborers. By steady driving the rows can be made very straight and the plants set more firmly than by hand. The furrow is closed in a second or two after it is opened, so that there is no time for the soil to dry out, and the roots are brought into intimate relation with the soil particles. Water may be applied at the same operation if necessary, and its use generally is profitable in giving the plants a quicker start even in fairly moist soil. A team, a driver, and two droppers can plant two or three acres a day at ordinary spacings; more when spacings are wide.

The plants may be set by hand by the use of dibbers or trowels or with the aid of special hand machines. Some growers open furrows with a narrow shovel-plow or a multiple row marker. When the furrow method is used, the plants should be set promptly, before the fresh soil becomes dry. Management of planting crews has been discussed (p. 130).

Cultivation.—On weedy land tillage usually should begin within a week after setting. It may be desirable, however, to delay the first cultivation of very early settings because frost is more severe over stirred soil. Immediate cultivation of plantings during very drying weather is likely to increase the loss of moisture.

The very early cultivations may be fairly deep to provide soil for smothering small weeds in the row. Later cultivations should be progressively more and more shallow to avoid serious root injury. The roots of cabbage spread rapidly and widely; many are close to the surface.

Cultivation after the plants begin to crowd in the row often reduces yields. If weeds compel such late cultivation the process should be more in the nature of scraping than of stirring the soil. It done during the heat of the day fewer leaves will be broken.

Harvesting.—When the demand is great and prices are high, it requires patience to wait until the crop is ready to market. Too much early cabbage is cut before the heads become sufficiently solid to hold up well, and soon the market is crowded with an inferior product. Crates are underweight. The cabbage is unattractive in display and disappointing in the kitchen. Sales always are restricted when much soft, loose cabbage finds its way to market. In waiting for proper maturity the increase in weight usually will make up for any decline in price. Sometimes the market improves after southern districts cease shipping.

Reed Bros.

FIG. 85.—Special cabbage cutting knife. Butcher knives are commonly used.

A butcher knife is a very satisfactory tool for cutting cabbage. The special knife, Fig. 85, developed by a New York cabbage and cabbage seed grower is a practical, speedy tool. In cutting, place one hand on the head, first determining, if necessary, its solidity; then, with the other hand, sever it while it is drawn to one side, retaining one or two close outer leaves to protect the head and make it more attractive. When the crop is to be stored in pits or houses, it is customary to retain two or three outer leaves for protection. If the cabbage is to be buried, a sharp hatchet is the most serviceable tool with which to cut the stems, retaining all the foliage.

As suggested, growers cultivating large fields generally plant so that a wagon or truck will straddle two rows. The early crop usually requires at least two or three cuttings but the late fall crop often may be cut clean at one operation. Cabbage should be handled with care to prevent bruising. An excellent plan is to keep a man on the wagon to catch and place the heads as rapidly as two or three men can cut and trim them. In like manner, one man can grade into two sizes, if necessary, and pack for two or three cutters if empty packages are placed conveniently for his use.

Marketing.—The most satisfactory way to sell is by weight, and this method if generally adopted would materially raise the quality of cabbage produced in various parts of the country.

Southern cabbage nearly always is marketed in crates. Perfect ventilation, protection from bruising, and compactness when loading on trucks or cars, make crates the best package for early cabbage. Northern growers make extensive use of both new and second-hand crates and second-hand potato or truck barrels. Ventilation in the barrels may be provided by chopping three or four vents in the sides after packing. Firm and close packing in the crates should be the aim, whether the cabbage is sold by the package or by weight. Cabbage is likely to keep better if it is dry when placed in the package, but this is not essential for most conditions.

A large proportion of the Danish type cabbage is sold in evenly weighted sacks containing 50 pounds. Sometimes larger sacks are used. Sacks are popular because they are cheaper and easier to store and handle than crates, but the cabbage suffers a great deal more from crushing and bruising.

After the weather becomes cool some of the late crop is shipped in bulk in open-slat cars. An inverted V-shaped ventilator is often made of rough boards and placed lengthwise in the center of the cars before loading when bulk shipments are made early in the fall. Refrigerator cars are necessary in warm weather and in very cold weather, with ice, of course, in the first case. During moderately cold weather tight box cars are suitable.

The question whether to market the late crop of Danish cab-

bage directly from the field or to store it sometimes perplexes the grower. As a rule the advance in price during the normal storage period is insufficient to make storage profitable when prices are average or lower at the time of harvest. On the contrary, when prices are higher than average at harvest, storage is more likely to prove profitable. That is equivalent to stating, "Store when the buyers offer a premium, and sell when they don't want it." Partial failure of the southern crop sometimes results in remunerative prices for good stored cabbage in late winter or early spring.

Bemis Bro. Bag Co.

Fig. 86.—Most of the late Danish type cabbage is packed in bags.

Storing.—A considerable percentage of the late crop is stored for later sale. Success in storing depends first upon the variety. We must look to the Danish Ballhead class to find the long keepers. Whatever storage method is employed, the aim must be to keep the cabbage in perfectly sound, fresh, crisp condition. The following conditions are essential:

1. The cabbage must be kept cool, preferably close to the freezing point. Low temperatures are unfavorable to decay (p. 205).

2. The air must be kept moist. A dry atmosphere causes cabbage to wilt, dry out, and lose its freshness and crispness.

3. Hard freezing must be prevented. Slight freezing does little harm, but a drop much below freezing may cause serious loss.

4. Although a certain amount of moisture is essential, an excessive amount must be avoided because it causes decay, especially if the temperature is high or the ventilation is poor.

To compete successfully with the attractive new cabbage from the South, much of the Danish type cabbage is kept in cold storage. It has become increasingly difficult to secure good prices for cabbage that has been stored for long periods without refrigeration. Most operators now move their holdings no later than January.

In common storage houses the cabbage may be placed in high narrow bins, or on shelves in tiers. The grower who contemplates such construction should visit and study the successful houses in the important northern shipping districts.

Some farmers store a few hundred heads of cabbage in the house cellar. If this can be kept cool, moist, and properly ventilated, the results generally are satisfactory. Most cellars, however, are not favorable and cabbage is an undesirable crop to have in the cellar of the residence in quantity. Bank storage cellars are satisfactory if well designed and constructed and if the storage period is not too long.

Various methods of burying or partial burying are in use. Where the winters are mild, little protection is necessary, and a suitable method is to draw a furrow 6 to 8 inches deep, pull, and place the plants in the trench with heads down, or on their sides. A furrow thrown from each side completes the work of burying. This makes a covering of about 1 foot of soil, which is ample for mild climates.

The following plan of burying cabbage has been successfully used in all parts of the North: The crop is cut with sharp hatchets, stubs 4 or 5 inches long being left for convenience in handling. If preferred, the heads may be gathered and hauled to a convenient, well-drained field near the building to be used in preparing the crop for market. The heads are placed on top of the ground, in long rows, three heads in width, side by side, the rows running up and down the slope of the land, to provide drainage. The usual custom is to invert the heads, but better protection is afforded by placing them on their sides, with the outer leaves beneath . A layer of cabbage one or two heads in width may be placed on top, but this increases the labor of covering. The windrows should be far enough apart to drive between them with a wagon.

After the crop has been placed in this manner a two-horse plow is used in drawing two furrows on each side of the windrows, as much soil as possible being thrown over the cabbage. The burying is finished with shovels, taking care to get 5 to 6 inches of soil over the cabbage. If heads are buried about the first or middle of November, the soil will afford sufficient protection for at least a month, when 3 or 4 inches of manure or straw should be thrown over the ridges. Additional protection may be used in the coldest localities. If more convenient, the outer covering of litter may be applied immediately after burying, but this may prove detrimental if the weather stays warm. If the cabbage is sound, there should be little loss from this method within a month or two, and it may be kept much longer if there are no prolonged periods of warm weather and if severe freezing is prevented.

An objection to burying is the inconvenience of taking out the cabbage in very cold weather. Large quantities, however, may be removed on the mildest days and stored in the barn or the cellar to meet daily demand.

Yields and returns.—Yields vary from a few tons to 25 tons an acre; even larger yields have been secured from small acres of high fertility. With approved methods they should not be less than 10 or 15 tons an acre. Average yields of shipping districts, however, often are below 10 tons an acre. Prices are extremely variable. At shipping points, they commonly range from \$10 to \$50 a ton for the early crop and \$5 to \$20 for the late crop. Higher and lower prices are recalled by most growers of long experience. The usual estimates for the cost of producing and marketing an acre of cabbage are too low; \$150 to \$200 an acre for early cabbage and at least one-third or one-half this amount for late are not too high. Large net returns seldom are secured without liberal outlay.

Sauerkraut.—Many gardeners and farmers make kraut for home use or local sale, especially when the market is weak, or when there is a considerable quantity of soft or over-mature cabbage. After removing the cores and outside leaves, the heads are sliced or shredded by special hand operated devices or machines. The finely cut cabbage then is placed in barrels in successive layers of about 6 inches, salted slightly and packed. This operation is repeated until the barrel is nearly full. About one pint of salt is required for a barrel of kraut. The cabbage is then covered with a cloth, and boards, cut to fit loosely in the barrel, are weighted heavily. The brine formed by the salt and the juice should cover the cabbage during the process, which is lactic acid fermentation.

The time required for curing depends largely upon the temperature, but it usually takes from two weeks to a month. While curing, the cabbage must be watched carefully to see that it is kept under

the brine. When fermentation is thought to be complete, samples for testing are secured from the interior of the barrel by means of a long wire hook. The kraut may be held in the barrels or removed and packed in containers of popular size.

Elaborate machinery and methods of control are used in commercial production of sauerkraut. The factories are supplied mainly from contracted acreage.

Seed growing.—To make proper selection of plants for seed it is desirable to have the heads nearly mature just before they are to be stored. On Long Island most late varieties are sown about June 15, while earliest varieties are not started until August. These dates for sowing would be 2 to 4 weeks too late for most northern states. The plants should not be grown in excessively rich soils, for very large heads do not winter well.

The roguing should be done as late as possible, discarding all heads not typical of the variety. Thorough winter protection must be given to both roots and tops. The plants may be buried where they were grown and the covering removed in the following spring. In this way a crop of seed may be produced without transplanting; but the more approved plan is to lift the plants and bury them before there is danger of hard freezing weather. Various methods are used to provide winter protection. One of the best plans is to place rows of three plants side by side in long trenches, made by plowing a furrow each way. The plants may be placed erect with the roots down, but better protection will be given by placing them at an angle of about 45 degrees. Two or 3 inches of soil are sufficient covering at first, although no injury will result from 6 inches of soil if the weather is cool. After the ground is frozen, several inches of manure should be added and, in the coldest regions, a foot of it might be used to advantage.

As soon as the ground can be worked in the spring the plants are removed from the trenches and set in rows about 3½ feet apart. Rather deep furrows are required to give the plants proper support, and ridging or staking must be resorted to later in the season when the seed stalks are developing. To allow the seed shoots to push through the heads with ease, the tops are cut crosswise at the time of planting.

The seed stalks are cut about July 1, or when the pods have turned yellow, and placed in rows to dry. From two to four days are generally required for drying. When dry, the stalks are loaded on a wagon, which should have a cloth covering extending around and reaching over the sides of the bed, to prevent loss of seed.

A tight floor is necessary for threshing, which may be done by flailing at any time after hauling from the field. The seed should be cleaned and thoroughly dried before storing. It usually takes

from 20 to 25 plants to make a pound of seed, though frequently two ounces are obtained from a plant.

INSECTS ATTACKING CABBAGE AND RELATED CROPS

Cabbage worms.—The common or imported cabbage worm *(Pontia rapac)* is the larva of the white butterfly that is familiar to all gardeners. The butterflies are active from early spring until late autumn and deposit small, pale yellowish eggs singly, usually on the undersides of the leaves. The eggs hatch in 4 to 10 days and the velvety green larvae which feed at first on the undersides of the leaves attain maturity in 10 to 14 days. The chrysalis stage during the summer months lasts from one to two weeks. The insect passes the winter in the chrysalis form attached to plants remaining in the field. There are three broods in the North in each season.

The cabbage looper *(Autographa brassicae)* is the larva of a moth having a wing spread of about 1½ inches, mottled brown front wings, each marked by a white spot, and grayish hind wings. The fully developed loopers are about 1½ inches in length, pale green with white stripes, and move with the looping motion peculiar to measuring worms. They are less common than the imported cabbage worm but are even more voracious feeders. Cabbage loopers may become numerous in the fall or last brood in which event they inflict very serious injury unless controlled.

The larvae of the Diamond-back moth *(Plutella maculipennis)* are brownish-headed, pale green worms a little less than one-half inch in length. They feed on the lower surfaces of the leaves, producing a characteristic riddled effect.

These and other less common species of cabbage worms may be controlled in the early stages of growth by spraying or dusting with calcium arsenate. Arsenicals must not be used, however, after the heads or attached foliage that goes to market begin to form. Rotenone and pyrethrum are very effective in killing cabbage worms and may be applied if necessary after harvesting begins. Many growers use rotenone even when the plants are small. About 15 to 30 pounds of dust are required to the acre. See Calcium arsenate and Rotenone (pp. 167, 168).

The cabbage aphis (*Aphis brassicae*) has been known in America for over a century and has become distributed throughout the country. Its destructiveness varies greatly from year to year, depending upon seasonal conditions and the prevalence of natural enemies. Protracted drought unquestionably favors the multiplication of this pest, while low temperatures with heavy rainfall are unfavorable. For example, in a dry season cabbage aphids have been known to ruin an unirrigated portion of a field, whereas injury was

negligible where water was applied weekly by the sprinkler system.

This insect usually appears in the North in the latter part of May or early in June, and feeds upon both upper and under sides of the leaves, causing them to curl. It multiplies with marvelous rapidity, producing 12 to 20 broods in a season. The bodies of the mature forms, which are green, are covered with a grayish, powdery coating that at a distance gives the appearance of mildew. The young are ready to reproduce in five or six days.

The eggs, which pass the winter attached to the stems and the refuse leaves, give rise to the first broods the next spring. This suggests the most effective means of prevention: all refuse in infested fields should be destroyed in the fall. It is important also to destroy remnants of infested plants from which the early crop has been harvested.

Spraying or dusting with nicotine may be employed before the leaves begin to curl, but dusting is more effective thereafter. Two or three per cent nicotine dusts generally are used (p. 166).

Because spraying or dusting with nicotine is relatively expensive, it is worth while to endeavor to prevent a general infestation. To accomplish this it may be necessary to spray or dust in the plant bed. If lice are present on purchased plants the foliage and stems, but not the roots, may be dipped, just before planting, in a solution made of 2 ounces of nicotine sulphate, one-half pound of soap, and 10 gallons of water. After planting, the field should be inspected frequently. Infested plants and adjacent plants should be dusted thoroughly with strong nicotine dust, preferably 3 or 4 per cent. Thus it may be possible to keep the insects in check and avoid the expense of applying an aphicide to the entire field.

The cabbage root maggot *(Hylemia brassicae)* is a serious pest in many localities, especially on the early crops of all crucifers and in the plant beds of late cabbage and cauliflower.

The adult resembles the common house fly, but is slightly smaller. Beginning early in the spring, tiny white eggs are deposited near the stems of the young plants, mostly in the upper one-quarter inch of soil where they may be discovered readily by searching with a knife point.

The eggs hatch in about a week or less under favorable conditions, and the larva feed on the underground portions of the stem and on the roots. If numerous they soon cut girdling grooves or channels in the stem and roots, burrow extensively, and eventually destroy the root system. Affected plants wilt on sunny days, become stunted, and die in great numbers when heavily infested.

During the growing season, the maggots mature in about 3 weeks and pupate in the soil around the infested plants, and about two weeks later a second brood of adults appears. Late broods are seri-

ous pests of fall radishes and turnips. The pupae from the last brood remain in the soil over winter.

In many localities the cabbage maggot must be combated as a matter of course. In others, the grower safely may delay treatment and sometimes can omit it entirely if he watches diligently for the eggs.

Control of maggots in the late cabbage or cauliflower plant bed is aided by choosing a breezy site, because the flies tend to assemble in sheltered places. Screening with 20 to 30 mesh cheesecloth often is practiced, although the covering should be removed about two weeks before transplanting into the field in order to accustom the plants to full sunlight and movements of air. Because percentage of germination and rapidity of growth are increased under screens, the customary rates of seeding and fertilizing should be reduced. The covering may be stretched over a framework or placed directly on the ground immediately after sowing.

Control on cabbage and related plants can be secured by the use of corrosive sublimate, one ounce of the powder or crystals dissolved in 10 gallons of water. The material, which is a deadly poison if taken internally, may be dissolved most conveniently in a small quantity of hot water, and diluted to the required amount. The solution may be applied with a knapsack sprayer, with nozzle removed; with a small apparatus designed for the purpose, or with a bucket and dipper.

A half cupful to the plant is required and it should be applied if possible when the soil is not too wet or dry, as the solution will then flow into the soil most readily. Avoid wetting the leaves, although damage is likely to result only to the more tender plants and those that have been attacked by flea beetles.

The first application may be made 3 to 5 days after setting early plants in the field. Or it may be withheld until frequent inspection reveals the presence of eggs. If inspection is done every 2 or 3 days, the application is more effective if made about 3 days after eggs are first discovered, at which time more eggs will have been deposited. The second application which should follow in 8 to 10 days often is sufficient. A third application may be necessary.

Corrosive sublimate solution, 1 ounce to 10 gallons of water, also is effective against maggots in the outdoor plant bed. The first application in early sowings should be made "when European plums of the green Gage type are in bloom" or 3 to 5 days after the seedlings come up in later plantings. A watering can with the sprinkler removed and the spout partially plugged to restrict the flow, or a can with a small hose attached may be used to pour the solution along the rows. A second, and perhaps a third application, with intervals of a week between are likely to be required. Because cauli-

nip, radish, horse-radish, and many cruciferous weeds. Its development is noted by decided yellowing, followed by death of affected parts of the leaf, the margins having a burnt appearance; the veins become brown or black and dark rings are observed in the stump. When leaves are removed at the stump, the fibro-vascular bundles appear as small black spots on the leaf scars. If badly infected, the plant is dwarfed or makes one-sided growth and often fails to mature. Because of black streaks, the heads are unsalable and frequently rot and fall off before marketable size has been attained. Preventive measures only are effective. No treatment will control the disease after it attacks.

Black rot often is introduced into clean areas by bacteria borne on the seed coats. The hot water treatment described for black leg also kills the seed-borne black rot organism. Or, if only the latter is present, soaking 30 minutes in a 1 to 1000 solution is sufficient. Once introduced it remains alive in the soil for at least 4 years. Preventive measures suggested for control of black-leg are applicable.

Yellows (caused by *Fusarium conglutinans*) is a very serious disease in a number of cabbage-producing districts, particularly where summers are hot and dry. The characteristic symptoms are stunting and yellowing of the plant, falling of the leaves beginning

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FIG. 88.—Yellows resistant cabbage at left and right, a susceptible variety in center, on yellows infested soil.

with the lower ones, and often severe infection on one side of the plant. The fungus grows in the water passages of the plant and darkens the woody portions of the main stems and roots. Affected plants may die, or continue to live in a weakened state, but they seldom produce marketable heads.

Control is impossible after the plant becomes infected. Sanitation and a rotation of 4 or 5 years are advisable; the organism, however, persists in the soil almost indefinitely after it is once established. Plants should be grown in disease-free or sterilized soil. Yellows-resistant sorts, some of which are mentioned in this chapter under Varieties, should be planted wherever infested soil must be used.

Root-knot (caused by *Heterodera radicicola*) is seldom serious to a great extent outdoors in the North. The characteristic smaller, comparatively regular swellings of the roots should not be confused with the larger, more distorted enlargements in club rot. The causative agents are microscopic eelworms or nematodes, control of which is discussed in Chapter X (p. 181).

Wire stem, really a phase of damping-off disease, frequently is noticeable as a progressive shriveling and darkening of the stems of plants under glass. It can be prevented for the most part by the use of disinfected soil, protective treatment of the seed, as with organic mercury dust, and correct ventilation and watering. It may be combated by applications of 1 to 1000 corrosive sublimate solutions as described for control of maggot and club root in the plant bed. Prompt watering should follow such treatment under glass and the leaves should not be wet with the solution (pp. 51, 52).

CAULIFLOWER (*Brassica oleracea*, var. *botrytis*)

History.—Cauliflower is of European origin and probably has been developed from broccoli. It is generally regarded as one of the most refined and delicate vegetables of the cabbage family. The heads are simply the shortened and thickened parts of the flowers. Cauliflower was probably first grown in this country for commercial purposes on Long Island. Its cultivation has been extended into many states, wherever suitable climatic conditions are found.

General requirements.—Except in the most favored sections, cauliflower is a difficult crop to grow. Many uncertainties attend its production. The young plants are very susceptible to damping-off fungi. Very low or very high temperatures, drought, or other checks to the growth of the young plants may cause them to "bolt" or "button"; that is, the heads either may break or send up their flowering parts before they have attained marketable size or they develop as premature small curds. Poor seed or dry weather at

the time of heading may cause the same trouble. Because of the uncertainty, many growers do not attempt cauliflower culture. Although the supply is liberal at times there is usually a good demand for heavy white heads.

Climate.—Proper climatic conditions are almost essential. Cauliflower requires a cool, moist growing season; it rebels against heat, dry weather, and low humidity; and it succeeds better when the days are relatively short. Regions near large bodies of water, as on Long Island, some localities around the Great Lakes, and Puget Sound areas furnish ideal conditions. Some inland sections, however, have had splendid success. As a rule, they are located at high altitudes where the air is cool and where fog or a moist atmosphere often prevails. High temperatures, low humidity, and lack of soil moisture or nutrients tend to check growth, reduce the size of the heads, and cause "buttons" as described. Overhead irrigation is especially valuable for this crop.

The plants are less hardy than cabbage. This fact must be taken into account when planting in the spring, although late spring planting is undesirable where summers are hot or dry. The maturing crop will stand light freezes but severe freezing will result in losses.

Soil.—A constant and liberal supply of moisture is the most important factor; good drainage, however, also is essential. The rich, heavy loams provide especially favorable conditions, although excellent crops are produced in light soils. Low, well-drained bottom land, even if sandy, produces good results if climatic conditions are satisfactory.

Varieties.—*Snowball* and *Erfurt*, which are available in many strains that differ greatly in respect to earliness, size of plant, size of head, length of leaves, and other factors, are by far the most generally planted varieties. It is important for the grower to seek the particular strains that suit his climate, methods of culture, and time of planting. The early varieties also are used extensively and successfully for the fall crop because they can be planted late to make most of their development after the heat of summer is declining and during the shorter days of fall.

Danish Giant or *Dry Weather* and other large growing late sorts are regarded as valuable for certain inland sections. These generally fail to mature when planted at the usual dates for the fall crop in the northeast.

Seed.—Most of the cauliflower seed used in the United States is grown in Denmark. For satisfactory seed production, conditions must be still more favorable than for the development of heads. Certain sections of Denmark, particularly in the vicinity of Copenhagen, furnish such requirements. While the bulk of our seed is

imported, there are producers of high-grade seed in this country. An ounce should be sufficient to grow 2,500 to 3,000 plants under glass or half as many in the open.

Growing plants.—Early cauliflower plants are started in the same way as early cabbage, but greater care must be exercised. The soil should be moderately rich and disinfected. There should be an even supply of moisture in the beds or flats, but overwatering must be guarded against carefully. Ventilation must not be neglected. The aim should be to produce moderate, healthy, unchecked growth from germination until the plants are established in the open ground.

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Fig. 89.—Cauliflower, of the larger Snowball type, showing desirable plant and head characteristics. Inner cupping leaves aid in protecting the curd.

As cauliflower plants are more tender than cabbage plants, it is customary to sow slightly later, March 1 probably being early enough for the coldest sections of the North. The plants then will be ready for the field early in May. Many growers prefer to transplant when the seedlings are very small, not more than an inch high. Planting them 2x2 inches apart does not give too much space, and provides free circulation of air around the plants, which may be removed from beds or flats with plenty of soil or compost, so that growth will not be checked materially by transplanting.

Methods used in growing late cabbage plants apply equally well to late cauliflower, except that more care must be taken. As the seed is much more expensive, it should be sowed sparingly, so that each seed will produce a good plant. Careful timing of sowing, so that the heads will neither come on before the cool fall weather nor be too late to mature, is essential to success. In general the later dates suggested for late cabbage are about right; that is, about June 1 to 15 in many parts of the North, although earlier or later dates or successive sowings may be more suitable locally.

Fertilizing.—Cauliflower requires even greater fertility than cabbage and should be fertilized liberally. Rotten manure may be used to advantage in large amounts, if obtainable at reasonable price, and is especially beneficial on sandy soils. With a good application of manure half a ton of fertilizer should be sufficient. With little or no manure 1500 to 2000 pounds of fertilizer often can be used to advantage. Analyses suggested for fertilizing cabbage generally are suitable. Under some conditions, boron must be included to prevent browning. Topdressing with nitrogen may be necessary to maintain steady growth. Lime must not be lacking. A reaction within the range pH 6.0 to 6.5 usually is most favorable.

Planting.—The early plants should not be planted in the open until there is no danger of very hard frosts, but the operation must not be delayed unduly. The late plants may be set from the latter part of June until August 1, as the locality and condition of the soil permit. The general practice is to plant the early crop so that the heads will form before the hot midsummer weather, and to start the late plants so that they will begin heading with the lower temperatures of the early fall months. Although the crop may be and is matured at midseason, the task is considered difficult, because heading does not progress so satisfactorily in hot, dry weather. Planting distances are the same as for cabbage.

Cultivation.—Clean tillage is required to prevent competition by weeds. In very small, intensive plantations, wheel hoes often are used; in field culture, fine-toothed cultivators are most popular. It is extremely important to avoid material injury to the root systems of the plants.

Blanching.—The market pays the highest prices for pure white heads, but these cannot be produced under most conditions without protection from rain and sunshine. This is accomplished by fastening the leaves over the heads in such a way as to shed rain and prevent the sun's rays from reaching the delicate heads. The operation should be attended to when the heads are very small. Almost daily attention may be required in warm weather. Generally several leaves are brought together and tied. Some growers prefer to break or bend a number of outside leaves over the heads. This

plan is satisfactory when the foliage is large or the weather is not too sunny. Toothpicks sometimes are used in fastening the leaves. A common practice is to tie with one color or kind of twine or rubber bands for 2 or 3 days and then use a different material for an equal period. Thus the cutters are enabled to take the heads that have been tied longest and proceed with minimum expenditure of time in examining the heads to determine their readiness.

Harvesting.—Frequent and regular harvesting is necessary to prevent overmaturity of many heads. The period from tying to cutting may range from 2 or 3 days in extremely warm weather to as many weeks late in the fall. The stage for cutting is determined by the condition of the curd rather than by size. Delay results in low market and table quality. The heads should be cut before the curds grow "riced" or become discolored. It is customary to retain one or two circles of outer leaves to protect the curd. The leaves usually are trimmed squarely across, with the remaining ends extending about an inch beyond the face of the curd. The curds are protected even better, however, when the heads are packed with the inner leaves untrimmed. Packing in two or three grades is customary. Crates are the preferred packages. As cauliflower is damaged easily it should be handled with greatest care.

Yields usually are 300 to 400 dozen marketable heads to the acre, often more than that from the fall crop, less from the spring crop, and least from the summer crop.

Cold Storage provides the only satisfactory means of holding cauliflower for more than very short periods. Even then the outside leaves soon become yellowish and the color and quality of the curd depreciate. The normal limit is two or three weeks, and that requires first-class conditions (p. 205).

Insects and diseases, and the control measures, are practically the same as with cabbage. Brown spots on the heads may be due to deficiency of boron (p. 102).

CAULIFLOWER BROCCOLI (*Brassica oleracea,* var. *botrytis*)

Characteristics.—The cauliflower type of broccoli closely resembles cauliflower and is thought to have been an ancestor of the present quick-growing cauliflowers. The plants are more hardy to frost than cauliflower and the heads require much more time to reach marketable size. Cauliflower broccoli is very sensitive to heat, requires a long period of evenly cool weather, and demands a liberal and constant supply of moisture.

Importance.—Broccoli is an important crop in England. In this country it is grown to some extent during the winter months, especially in milder parts of Washington, Oregon, California, and Louisi-

ana. The plants are carried over winter in the field and produce heads during February, March, and April.

Culture.—In general the culture is the same as for cauliflower except that more space and time are required. The season of suitable growing weather is too short in the Northeast. *St. Valentine* is the principal variety grown in the United States.

SPROUTING BROCCOLI (*Brassica oleracea*, var. *italica*)

Characteristics.—The sprouting type of broccoli generally is considered to have been the form from which the white or cauliflower broccoli was developed. Commonly known as *Green-sprouting* or *Calabrese* broccoli, it has long been grown and extensively used in Italy. This vegetable has become popular in the United States only within recent years. Its commercial importance is increasing rapidly.

The usual types first develop a central head of green color but otherwise are similar to cauliflower. When the central head is cut, a number of smaller axillary stalks develop and bear smaller heads which are sold in bunches. Sprouting broccoli is a vegetable of the highest quality.

Culture.—The selection and preparation of soils, methods of growing plants, fertilization and general culture described for cabbage and cauliflower are equally suitable for sprouting broccoli. However, broccoli should be allowed 18 to 24 inches between plants in the rows and about 30 to 36 inches between rows. *Italian Green Sprouting* or *Calabrese* is the common variety.

Harvesting.—The correct stage for cutting occurs shortly before the buds begin to open, while the heads remain compact. A little later, after some of the buds open and the heads become spreading, the quality is low. The total length cut is about 8 or 10 inches. The axillary shoots, as they develop, are cut at the same stage as the central heads.

Marketing.—Green sprouting broccoli is one of the most perishable vegetables; after cutting it quickly turns yellow and becomes unsalable in hot weather. The best practice is to pack with liberal quantities of crushed ice in crates lined with moisture-resistant paper. It may be advisable to have the volume of ice equal or exceed the bulk of the vegetable.

Certain types of seven-top turnips are grown and sold in some localities as "broccoli," which is the Italian for turnip. The overwintered plants produce marketable clusters early in the spring and are harvested in the bud stage. They are less popular than green sprouting broccoli.

Insects and diseases.—The general methods of prevention and control described for insects and diseases attacking cabbage apply to the culture of sprouting broccoli. It should be noted, however, that both aphids and cabbage worms seem to thrive in the heads of this vegetable. In addition to their direct injury, their presence is very objectionable to the housekeeper who finds it almost impossible to wash off the insects. For aphids apply a 3 or 4 per cent nicotine dust very thoroughly. Rotenone dusts or sprays are safe and effective against the worms as well.

BRUSSELS SPROUTS (*Brassica oleracea*, var. *gemmifera*)

Characteristics.—Brussels sprouts are one of the many variations of cabbage. Instead of a single head at the top of the stem, a large bud or miniature head is borne in the axil of each leaf, so that little heads are distributed all along the tall stem, which is crowned with a cluster of loose leaves. The solid little heads or "sprouts" from 1 to 2 inches in diameter are tender and delicious. This excellent vegetable is used most during fall and winter months, and deserves wider appreciation.

Culture.—The climatic requirements and culture are practically the same as for cauliflower. Well-bred seed is exceedingly important. Sowings may be made under glass the first part of February, transplanting the seedlings to the cold frame in March and to the open ground in April. The plants are slightly less hardy than cabbage. For the late crop, sowings should be made in the open during May, the transplanting about six weeks later. Successive sowings may be made. A deep, rich, moist soil is required for best results. The plants should be spaced about 18 inches apart in rows 30 to 36 inches apart. Nitrate of soda often can be used to advantage in addition to stable manure or complete fertilizer.

The miniature heads form on the late plants toward the end of the summer. Ordinarily the leaf below each mature sprout is broken away at the time of harvest. As leaves and sprouts are removed progressively, from the base upward, elongation of the stem and production of leaves and sprouts occur at the top. The lower sprouts, including poorly developed ones, should be harvested clean.

The sprouts are thought to improve in quality with frost, and are therefore most in demand during the late fall and winter. The plants may be stored during the winter by the methods used for cabbage but the commercial crop is generally packed in 50-pound drums with liberal amounts of crushed ice and placed in cold storage. It is marketed in quart containers. The leading variety is *Long Island Improved*. Yields to the acre run from 2000 to 5000 quarts.

CHINESE CABBAGE (*Brassica pekinensis*)

This vegetable is of limited importance commercially, but is increasing slowly in popularity. It is used both as a potherb and as a salad. Although comparatively new in this country it is said to have been grown in China for about 1500 years.

Chinese cabbage requires a highly fertile soil liberally fertilized in the general manner described for cauliflower and cabbage. Muck soils are very desirable for this crop. Irrigation is a great aid. *Chihli* is the most important variety.

It is almost impossible to produce Chinese cabbage as a spring crop because the plants invariably go to seed. The fall crop usually is grown most successfully by seeding where the plants are to mature because the shock of transplanting encourages the development of seed stalks. July and early August includes the most favorable seeding times for many parts of the North. When the plants are not over 2 inches high they should be thinned to stand about 15 to 20 inches apart.

Harvesting and storing.—Chinese cabbage should be cut when the heads are fairly firm. The outer leaves are removed to display the blanched center for market, or some are left on if it is to be stored. The crop will keep a few weeks in common storage, or several months in the best cold storages.

Arsenicals can not be used with safety in combating insects on Chinese cabbage. Pyrethrum or rotenone preparations are recommended.

KOHLRABI (*Brassica caulorapa*)

Importance.—This vegetable is often called "Turnip-rooted cabbage." It is closely related to cabbage and easily grown as a spring or fall crop. The stem, which is the edible part, is greatly enlarged immediately above ground. It is not widely popular. When cooked before the flesh becomes woody, it is especially delicious.

White Vienna is the leading variety.

Culture.—The early varieties may be forced in cold frames and a much earlier crop may be procured in the open by starting the plants under glass and transplanting in the field where the crop is to mature. The plants require the same general treatment as cabbage.

However, it is customary to sow the seed where the crop is to mature and to thin the plants to 8 inches apart in the rows. Fifteen inches between rows is sufficient to permit satisfactory tillage with wheel hoes. The seed resembles cabbage seed and should be sown at the same depth.

Marketing.—It is important to market the crop before the en-
rgements become woody. The plants may be tied in bunches like
rly beets or sold in bulk. Kohlrabi is a profitable crop whenever
market can be found. It may be stored in the same manner as
ot crops.

XIV

SALAD CROPS

The salad crops are the leafy vegetables which are usually eaten uncooked. They are valued for their attractive appearance, appetiz- ing succulence, bulk, and vitamin and mineral content. No dinner is complete without including one or more salad vegetables.

Improved packing and transportation and growing appreciation of the palatability of well grown raw vegetables and their regulatory influences in human nutrition have increased the use of all salad vegetables and of celery and lettuce in particular. The latter have become commercially two of the more important vegetable crops.

In general the salad crops thrive best during the cooler, more moist portions of the growing season and are difficult to grow well when temperatures are high or soil conditions are unfavorable. Large scale commercial production is confined to areas of favorable environmental conditions.

CELERY (*Apium graveolens* var. *dulce*)

History.—Celery is native to the Mediterranean region. The wild plants have a rank flavor and were thought to be poisonous. Very little is known concerning its early history, but celery was probably not cultivated as a food plant until after the Middle Ages. The many varieties now in cultivation are the developments of com- paratively recent years. Varieties with solid rather than hollow stalks attracted attention about the beginning of the last century. As late as 1880 this vegetable was unknown to many Americans and very little was grown commercially. It was then regarded as a luxury, selling at high prices, for use in garnishing and flavoring and for salad purposes.

Importance.—Celery is one of the most important vegetables. Extensive areas of muck lands in Michigan, Ohio, and New York are devoted to this crop. The industry has become of great impor- tance also in California and Florida. With the varied climatic con- ditions of these and other states which are producing celery on a large scale, our markets are well supplied during most of the year. Eastern growers as well as western producers begin marketing in July or earlier and continue to supply the trade until January. Florida and California crops are ready the latter part of December and meet the demands until late in the spring. Celery is an im-

portant crop among market gardeners nearly everywhere. In fact, intensive market gardeners of the North consider celery one of their most profitable crops, especially with the overhead system of irrigation.

Climatic requirements.—Celery is grown successfully in all parts of the United States. Certain climatic conditions, however, are especially favorable for its most successful culture. Low humidity, plenty of sunshine, considerable warmth during the day, and cool nights provide ideal conditions. Diseases are less troublesome when the air is dry, and rapid but strong, healthy growth is encouraged by sunshine and moderately high day temperature. Cool nights make the leafstalks firm and crisp. Most northern sections provide excellent conditions during the summer and fall, while some parts of the South, especially Florida, possess the proper climatic conditions for winter culture.

Although celery is one of the hardy vegetables, it will not stand severe freezing without sustaining injuries. The young plants are likely to be checked in growth by hard spring frosts. The mature plants often are damaged by severe freezing. Vigorous plants may stand a drop of about seven degrees below freezing, although this will impair market condition and keeping quality. Liberal rainfall, well distributed during the growing season, is necessary unless the crop is irrigated.

Celery is a biennial but is grown as an annual vegetable. If seed is sown very early and the plants are exposed to prolonged low temperatures, however, they may produce flowers during the first year. This is sometimes a source of heavy loss in plantings of early celery.

Soils.—A very large proportion of the commercial celery crop is produced in the states bordering on the Great Lakes, in California, and in Florida, and is planted on muck or peat soils. These soils are especially adapted to celery because they have very high water holding capacity and are moist, loose, and friable. As they are easily worked, and irrigation is not so likely to be required, it costs less to grow a crop on such land than in other soils. A first-class muck is brown-black in color, friable, and free from coarse, fibrous material. It should be not less than 18 inches in depth to secure the most satisfactory results. In the best celery mucks the water table is about 3 feet below the surface. In such soil the crop will not suffer seriously during drought. When the water table is too near the surface the soil is soft and difficult to work with horses or tractors and there is danger of an excessive amount of water in wet seasons.

New mucks of strongly acid character, lower than about pH 5, are unfit for celery until they are limed. If the reaction is very low, below pH 4.6, the quantity of lime required to effect sufficient

Salt Lake is a relatively quickly blanching green celery tha intermediate between Easy Blanching and Pascal in depth of c and time of blanching. It is a vigorous grower that produces th leaf stalks with prominent ribs, and a very full heart. Qualit good. *Utah* may be synonymous, or similar, and is darker gr and taller in some strains.

Giant Pascal, an old green variety of highest quality, is gain new popularity. Lack of fullness in the heart is characteristic the leaf stalks are easily broken in handling. The short, rather t the tall, strains are preferred by most gardeners because blanch is less laborious, the hearts usually are fuller, and there is less d age in handling. The leafstalks are round edged, comparativ smooth, and palatable even when green. Pascal is planted ma as a late crop. Summer Pascal is a new earlier strain.

Emperor, practically synonymous in most strains with *Fordh* or *Houser*, is a distinct variety of short growth and comparati spreading habit. The leafstalks are exceptionally brittle, th meaty, rounded, and smooth. It is especially popular among ho gardeners and in some markets. As Emperor is very fragile, h ever, it is poorly adapted for shipping.

Sources of seed.—The planting of high-grade seed is of pr importance, for a poor strain may be a contributory cause of p or hollow stalks, running to seed the first year, failure to get a g stand of plants, and lack of vigor and uniformity. Much seec the self-blanching varieties is grown in France. Seed of the gr sorts is produced largely in California. Some growers produce t own seed, but most gardeners purchase their supplies from reli dealers or growers who are specialists.

Fresh seed is advocated by many growers, although a few c ful gardeners prefer to buy a large quantity, test it for one y and then use the seed from year to year until the supply is exhaus With favorable storage, the germinating power of the seeds may retained from six to eight years. Spores of late blight, which carried on the seed, generally do not live longer than three ye nevertheless, treatment for seed-borne diseases should be a reg practice (p. 22).

To produce seed of celery on the farm, the best stalks are li and stored over winter. Early in the spring these are planted doors. When most of the clusters are ripe, the plants are pulled hung in a dry, airy place for curing. After the seed is thorou ripened it may be beaten out, winnowed, and stored. Seed sh not be saved from premature seeders in the field. It is permiss however, to sow well-bred seed very early, perhaps January 1, ject the plants to several weeks of low temperatures, in cold fra and thereby force premature seeding of practically the entire

process, however, should not be carried beyond one generation. ...ted stock seed always should be used.

Sprouting the seed before planting is practiced by many ...y growers as a means of getting the seedlings above ground ... certainly and quickly. Details of procedure vary. Usually ...seed is mixed with a little finely sifted moist muck or composted ... or it is sprouted between folds of moist cloth. Some growers ...ly soak it in water for 24 hours, or place the wet seed in a pan ... stir it lightly every few hours. Long soaking is detrimental and ...outing should not be continued after the appearance of white ... The moist seed, after it is partially dry, may be planted im...diately without difficulty when mixed with fine dry soil, sand, or ... meal.

Growing early plants.—When extreme earliness is not a con...ration and plenty of space is available from the date of sowing, ...ay be most economical and satisfactory to sow thinly and not ...plant before the plants go to the field. Most growers, however, ...plant plants once for the early crop.

Celery seed, which is very small and slow to germinate, must be ...vided with favorable conditions in the seed bed. The soil should ...ine, moist, and not inclined to bake. Muck is used when avail... It is improved by the addition of sand and a small quantity ...one meal. If muck is not available use any rich soil to which ...ral amounts of sand and fine rotten manure have been added. ...ably composted soil is excellent. Where damping-off or other ...ases of celery are troublesome, the only safe course is to disin... the soil with steam or formaldehyde, or to procure new, clean ...

Time of sowing is determined by climatic conditions, the desired ... of harvest, and methods and facilities for plant growing. Where ...plants cannot safely be set in the open until about May 1, it is ...cult to maintain unchecked growth when the seed has been ... very much before March 1.

The seed may be sown in flats or in the soil of the hotbed or greenhouse. If flats are used, the soil must be moist and well ...ed, especially in the corners and along the sides. The seeds ...rally are sown thinly in rows about 2 inches apart. The fur... are made very shallow, so that the seeds will not be covered ... more than ⅛ inch of soil. After the seed is covered, a piece ...urlap often is placed over the flat or the bed and the soil is ...tened by sprinkling over the covering. Germination will be ... greatly in sunny weather if the burlap is left in place or the ...s covered with paper until the seedlings begin to appear.

...f possible, a temperature of about 70° to 75° F. is maintained ... the plants emerge. They must then have plenty of light, sun-

shine, and fresh air. Ventilation, however, should be provided w discretion; excesses must be avoided. Water as often as necess to keep the soil moist, but avoid overwatering. If the stand is th and the seedlings are not to be transplanted before they are tra ferred to the field, thinning may be necessary.

Temperatures, as suggested in Chapter IV, Plant Growi should be kept sufficiently high, about 65° to 70° F., to maint vigorous, uninterrupted growth. With the earliest sowings, spe care must be taken to avoid carrying the plants for more than v short periods at temperatures below 50° F. Prolonged exposure low temperatures in seed bed, cold frame or field is contributory seed production in the first year.

The tiny seedlings usually are shifted when the second lea appear. Beds provide more even moisture but good plants can grown in either flats or beds. A spacing of one and one-half inc each way is generally ample, and some growers plant only inches apart, but, if they are to be held for a long period, it is bet to plant 2 by 2 inches.

The soil for transplanting celery plants should be very fert The practice among some growers who use flats is to fill them h full with thoroughly rotten manure and then completely fill w good soil or compost containing plenty of rotten manure and sc sand. The flats should be kept in the hotbed or the greenho until the plants are well established and are making vigor growth. The plants should not be put in the cold frame until sev weather is past. Young celery plants require about as much h as tomato seedlings. A necessary precaution against foliage disea is to keep the plants protected by frequent application of borde mixture or 20-80 copper lime dust. Sufficient hardening may induced by watering sparingly during the last 8 or 10 days bef field setting.

Growing late plants.—Seed for the late crop in the North u ually is sown in the open nearly as early in the spring as the grou can be prepared. In the colder areas, or, if a slightly earlier crop wanted, it may be sown in beds protected by muslin coverin Windbreaks often are an advantage. In warmer sections, where sun is very strong during the plant growing period, it may be nec sary to employ cloth or lattice screens to partially shade the b until the plants are well established. It is customary to grow plants to the desired size for field setting without preliminary tra planting in the plant bed.

The soil should be sufficiently friable to permit the delic plants to push through to the surface, relatively free from wee and uncontaminated by celery diseases, otherwise disinfection essential. Early plowing promotes conservation of moisture wh

necessary to assure a good stand of plants. By sowing time the il should be worked into fine, smooth, and moderately compact ndition. Sometimes the land is thrown up into beds a few feet de, although this is unnecessary in well drained locations.

On rather weed-free soil the seed is often broadcast at the approximate rate of a level teaspoonful to the area of a standard hotd sash, or ½ to 1 ounce to 100 square feet of bed. Covering is complished by very light raking or brushing. Compacting by ling or by firming with a board may or may not be advantageous cording to type of soil, amount of moisture present, and weather nditions.

Sowing in drills about a foot apart usually is better than broadcting outdoors, because the soil may then be cultivated. Care st be exercised to provide only a very slight covering of fine soil. the weather is dry, frequent light waterings may be necessary til the plants become established. Fungicides should be used as otection against blights, and weeds must be controlled fully. eir presence favors the production of weak, spindly plants and of ease infections because penetration of light and air is impeded. dinarily about 4 ounces of celery seed are used to assure plants an acre of the crop, or 1 ounce to 8,000 to 10,000 plants. A le time may be saved as a rule by soaking or sprouting the seed y slightly before sowing.

Manuring.—In making plans for the fertilizing of this crop the wer should bear in mind: (1) that the root system is shallow d not widely distributed; (2) that the plants prefer soils abound- in organic matter; (3) that rapid growth is essential to large lds and high quality. Plants which grow slowly are not so atctive, crisp, sweet, or tender.

On muck, stable manure is used mostly to inoculate new lands l for the old muck that is getting "cheesy." Rates of application relatively light, as a rule. On mineral soils nearly all celery wers apply manure if it can be obtained at reasonable prices e amount of manure to the acre varies from 10 to 50 tons. Insive growers, who figure on gross returns of not less than $1,000 acre, sometimes apply 50 tons, but equal results often may be ured with one-half this amount or less, if supplemented with mercial fertilizers. The largest crops are most easily secured h liberal use of stable manures. There are many celery growers, vever, who depend entirely on green manurial crops and comrcial fertilizers. In order to be successful with this system on eral soils the grower must be well informed on the principles of management and thoroughgoing in his methods.

Rotten manure is preferred by many growers while others make ter applications of fresh manure. When the latter plan is prac-

ticed the manure should be chopped up and thoroughly mixed with the soil by means of a disc harrow before plowing. Best results with rotten manure are obtained from dressings applied after plowing; the most approved plan is to spread broadcast. Formerly, many growers bedded the manure in trenches or furrows before planting, but few continue this practice. Mulching with manure is described later.

Commercial fertilizers.—While some growers rely wholly upon stable manure, commercial fertilizers always can be included with profit. Rates of preplanting applications range from 1000 to 1500 pounds, with manure or a good leguminous sod, and to 1500 or 2000 pounds to the acre without manure. Applications of more than a ton to the acre are not uncommon, but they are of doubtful economy under average conditions and are unlikely to prove necessary when active organic matter and lime are adequately supplied. It is customary to broadcast or drill the fertilizer and harrow thoroughly.

Representative applications are 1000 to 1500 pounds of 4-12-4 on fertile upland soils with manure or clover, and 1500 to 2000 pounds of 4-10-6 or 5-10-5 on loams of average fertility without much manure or without a succulent green manure of considerable tonnage. Under such conditions some growers prefer 7-6-6. On mucks the analyses 4-8-12, 3-12-15, 2-8-16, and 0-8-24 are commonly used, the quantity of manure and the age and state of the muck determining the ratio of nitrogen, which should be higher for early crops and for soils which contain little active organic matter.

At least one, and usually several top-dressings or side dressings are needed on many soils to supply additional nitrogen. The first application may be made when the plants have become well established. Others may follow as required, usually at intervals of two or three weeks. Two hundred pounds of nitrate of soda or 160 pounds of sulphate of ammonia, or the equivalent, are the usual rates of application. In some cases potassium, also, and even complete fertilizers are considered more desirable for post-planting fertilization. Soft or pithy stalks and poor keeping quality sometimes are attributed to too much nitrogen. It is claimed that the free use of the mineral elements will counteract this effect by producing firmer stalks. On certain soils the addition of boron to the fertilizer (p. 102) has been effective in reducing cracking of the stems.

Although celery is sensitive to acidity, particularly on mineral soils, excessive liming is to be avoided as conducive to nutritional difficulties. A soil reaction of about pH 6 to 6.5 generally is recommended.

Planting.—As previously explained, plants for the early crop should not be set in the open until after danger of severe frosts. In

many northern sections plantings should not occur until May 1 or 10. Strong, vigorous plants properly set at this time should produce a marketable crop by August 1 or earlier. The late plants may be set the latter part of June and throughout the month of July, depending upon variety, soil, weather, and climatic conditions.

If the plants are more than 6 or 8 inches high at the time of transplanting it usually is an advantage to clip the tops. This operation is sometimes performed in the plant bed, especially when field planting is delayed.

The ground should be fine, smooth, moist, and fairly firm before transplanting is begun.

Planting distances are extremely variable. When paper and boards are used for blanching the spacing between rows is usually from 24 to 36 inches. If soil is to be used, the distance between rows must not be less than 4 feet; 5 feet is the more common spacing, especially for the tall green varieties. Sometimes an early variety, such as Golden Plume, is planted in alternate rows. It is blanched by means of boards or paper. The distance in this case need not be more than 30 inches. After the early crop is sold there is ample space to blanch the late crop with soil.

The standard distance between plants in the row is 6 inches. A few intensive growers plant early varieties only 4 or 5 inches apart and allow about 24 inches between the rows. Double-row planting is practiced in some localities. With this method, the rows of a pair are about 6 or 8 inches apart and a space of 30 inches or more is provided between the pairs of rows. At the very close distances 65,000 plants or more are required for an acre, but the usual number is about 30,000 to 40,000. Close planting favors the development of disease and with double rows control of weeds may be more difficult. Like other very intensive methods unusual close planting should be undertaken on only very fertile lands where the supply of moisture can be maintained.

Plants can be transplanted to better advantage in humid or cloudy weather. They should be lifted with care. If the seed beds or flats have been watered 24 hours in advance, the plants can be removed with more soil on the roots and less injury than if they are unwatered. Dibbers, trowels, or the forefingers are used in making the holes for seedling plants, which should not be set deeper than in the flats or beds. Large seedlings or transplanted plants may be set conveniently and rapidly in shallow, narrow furrows. Pressing the soil firmly to the roots completes the operation of transplanting.

Various forms of markers are employed, but shoe and wheel markers are most popular. The wheel markers may have pegs to mark the place for each plant in order to secure uniformity in spacing. They relieve the foreman of the annoyance of looking

after this matter. Straight equidistant rows are necessary for the best cultivation and for even coverage in multiple-row spraying and dusting.

In dry times it is common practice to run water into the small furrows just ahead of the planters. When sprinkler irrigation equipment is available, water should be applied as soon as the last planter is out of the way. To reduce the length of time before water can be applied, planters may be put to work at several places on long rows. Under hot windy conditions celery that is irrigated immediately after planting nearly always produces a much heavier and more uniform crop than where watering is delayed only an hour. Irrigating several hours or a day before transplanting is an advantage when the soil is dry.

Celery transplanting machines designed for the purpose are altogether practical on finely prepared soils. In fact, ordinary transplanters may be used with some tractors that have gears for very slow speeds. A speed of 1 mile per hour is about the maximum to permit 6-inch spacings. Some growers plant 12 inches apart with the same machine used for cabbage and other crops. Intermediate plants are then set by hand, the entire row having been watered by the machine.

Whatever the method of planting, it is essential to set celery just to the level of the crown; there is little allowable variation in depth.

Cultivation.—The ground should be cultivated as soon as possible after transplanting, taking precaution not to work any soil up on the hearts of the plants. As the root system of celery is shallow and of small radius, deep tillage close to the rows may be very detrimental. The ground should be stirred and hoed often enough to control weeds and to maintain a thin, loose surface layer of soil.

Mulching.—Pine needles, straw, and other materials are used sometimes for mulching celery, but horse manure is the best mulch. It is not only an excellent conserver of moisture, but also furnishes nutrient materials. Additional top-dressing with nitrogen may be required with very strawy material. Some of the most successful intensive growers use the following plan: the plants are set at the usual time, at distances of 4 or 5 inches by 24 inches; as soon as possible after transplanting, the ground is mulched with 40 to 50 tons of fresh horse manure to the acre, which must not be placed against the plants. If applied at the rate suggested, the mulch will be 4 or 5 inches deep at the center of the row spaces, sloping gradually to the rows themselves. No tillage is given if the mulch is applied immediately after planting, otherwise the ground should be kept well stirred until mulched. The manure will be thoroughly

decayed by the following spring, ready for whatever crop may follow.

Irrigation.—Celery production without artificial watering on soils other than muck is rather uncertain, as both yield and quantity may be inferior. The supply of moisture must be ample at all times to assure a good crop. In fact irrigation is almost a necessity on many areas even of the organic soils. It is especially valuable at the time of planting, to dissolve nitrates into the soil after broadcasting in dry weather, and to accelerate the blanching process when rainfall is insufficient. The furrow system is used chiefly in the West; sub-irrigation is ideal where it is practicable to control the water level of the soil, as at Sanford, Florida, and sprinkler or overhead equipment is most common in the celery fields of the eastern and central states.

Blanching.—Most markets demand well-blanched celery which is secured by causing the plants to grow for a time with the leaf stalks in subdued light or darkness. Growth under such conditions destroys the coloring matter. Any means of excluding light will produce blanched stalks if growth processes are active. Proper blanching makes celery more tender and crisp and makes the flavor milder.

For many years celery was grown mainly as a fall crop and banking with earth was the usual means of blanching. When blanched with soil the stalks attain a sweet, nutty flavor that is difficult to produce by other methods. Banking, ridging, or hilling, as it is variously called, continues to be an important method with

Skinner Irrigation Co.

Fig. 91.—Blanching celery by banking or hilling with earth.

the late crop in many localities. Banking is unsuitable for the
crop because it often results in so-called rusting of the stalks if
weather prevails. When the crop is to be stored in trenches or
where at temperatures high enough to encourage some growth
ery will blanch to a certain degree during storage and will
better if blanched only a little or just enough to "raise the hear
the field.

Ridging may begin with the cooler fall weather. Formerly a
celery was first "handled" before the ground was plowed up t
rows. Many growers continue the practice, while others do a
ridging with special celery hillers. By handling is meant the p
ing by hand of loose, moist soil about the base of each pla
make the stalks stand erect. Tillage precedes this operatio
provide plenty of fine soil. The hiller is used immediately
handling and subsequently as the plants attain greater heig
become more erect. All of the work of ridging in some of the
plantations is done with the hiller. Some growers ridge the
high along the rows rather than against them. This practice re
in shading without applying much soil to the bases of the p
which encourages rust. Banking or hilling is the most effe
means of protecting the crop from severe fall frosts.

When the crop must be blanched during warm weather th
of boards or paper, usually 10 or 12 inches wide, is necessary
It may be most convenient and economical in the cool season.
early crop in various parts of the North is ready to blanch in
or early in August. Blanching usually is started as soon a
plants attain acceptable market size. Approximately 7 to 20
are required for blanching, depending mainly on weather c
tions. In warm, humid weather, blanching proceeds more ra
than at lower temperatures. The papers or boards are shifte
other rows or plantings as harvesting proceeds and are use
turn) several times in one season.

Boards are placed on edge close to the row on both sides a
necessary, are fastened together with 8-inch double hooks ma
heavy galvanized wire. By placing these hooks over the
edges, the boards may be brought as close together as the to
the plants will permit. A light furrow of soil often is thrown
the lower edges of boards to exclude the light, or to reduce
from freezing late in the fall. Between seasons the lumber s
be stored in a dry place or stacked in flat piles as in lumber y
With good care, sound boards will last at least 15 years.

Special weather-resistant, cord-containing papers are now
most extensively in blanching celery. A strip is applied to
side of the row. These are fastened in place by large stap
stiff wire, the ends of which are pushed several inches into the

arge plantings simple machines are useful in applying and re-ng the paper. Manufacturers of celery paper will supply speci-tions for construction. Paper is less expensive and laborious to than lumber for blanching celery, but boards are more durable are convenient where small amounts of celery are harvested at uent intervals. Individual paper wrappers in the shape of tubes 12-inch lengths of ordinary farm drain tile are useful for blanch-celery in small plantings.

J. P. Gilson Co.

Fig. 91.—Blanching celery with paper.

Harvesting.—The best time to harvest is determined by the size he plants, thoroughness of blanching, prices, and weather con-ns. The market will sometimes pay better prices for very y celery, partly blanched and two-thirds grown, than for late, l sized, perfectly blanched stalks.

The usual method on a small scale is to lift the plants with a el or fork or to cut the roots at the proper depth with a large, o butcher knife. The latter plan is especially satisfactory in y or muck soils and when the crop has been blanched with ds. In large plantings, machines are employed to sever the

roots at the proper depth. They are equipped with a U-shaped stee cutter mounted beneath and between two wheels, or adapted to two-row, riding cultivator. It is adjustable, so that it may be raise or lowered as desired. The operator can guage the depth by th character of the sound of the cutting. For storage, especially i trenches or pits, several inches of the roots should be retaine Prompt movement to the packing house, car, or storage is necessar to prevent wilting in bright weather.

Caterpillar Tractor Co.

FIG. 93.—Efficiency in harvesting a heavy crop of celery. Four wagons in a train enable the men to work expeditiously. Wagons may be moved into the packing house to avoid rehandling before trimming.

Packing and marketing.—In some instances the crop is shippe in the rough direct from the field to city storage houses, or to com mission dealers. When this practice is followed a few of the outsid leaves are removed before it is packed in the field. Growers in cer tain sections ship the crop without removing or trimming the roots although most producers find this necessary. The roots may b cut off straight near the base of the stalks or tapered abruptly to blunt point. Celery for shipment usually is graded into about sizes and packed erect, unbunched, in crates. The preferred siz of crate differs with localities.

Thorough washing, which helps secure the bright appearanc that attracts buyers, is becoming a more general practice than fo merly. Liberal use of pure, very cold water freshens and helps pr serve the celery in firm, crisp condition. Washed celery that is we blanched, free from disease, and tastefully trimmed enjoys conside

ble sales advantage. In warm weather celery must be shipped nder refrigeration, especially when washed.

In some sections celery is trimmed quite closely, washed clean, nd packed with or without crushed ice, according to the time of year and distance of shipment, in paper-lined crates or rectangular baskets.

For local markets celery often is tied in flat or round bunches that usually contain three plants, and, for some markets, in round or rectangular bunches of 12 plants. Use of colored tape helps make the bunches attractive. Parchment paper and cellophane are commonly employed to pack celery hearts and rubber bands of suitable size are used extensively for securing the smaller bunches.

Storing.—Storage of celery has declined because some districts now ship at all seasons. For successful storage of celery the air must be kept cool and fairly moist. The crop should be stored before hard freezing weather and the tops should be dry when the plants are packed. Only good celery should be stored. Diseased celery is certain to cause trouble in storage, especially if the temperature rises much above 35° F (p. 205). Celery intended for storage should be protected thoroughly with fungicides throughout the growing season and just before storing.

Limited quantities can be stored in cellars. The plan is successful when there are no furnaces and heating pipes, for the room must be kept cool and moist. The plants are set close together, with some soil about the roots, and are watered as necessary. Boards may be placed along the sides of the bedded plants to keep them in place and to protect them from light. Under favorable conditions there will be some growth and the plants will continue to blanch.

Market gardeners sometimes ridge as high as possible, place a ine of hay or straw over the tops, cover with a strip of oiled paper uitable for the purpose, and then cover the paper with more litter. This plan is particularly desirable in sections where the weather is not very severe. A variation of this method is to place corn stalks or other coarse litter over the tops of the ridges and to cover with boards or earth. As the weather gets colder coarse litter is added to a depth of 4 or 5 inches, covering the entire ridge. By this method he celery is kept fresh and crisp, but it is rather inconvenient to ake it out during bad weather.

Hotbeds and cold frames are fairly satisfactory for short periods. They may be dug to greater depth if necessary, or an additional rame may be placed on the permanent frame to secure the required epth. The plants are set with a little soil about the roots, nearly as ose together as possible, and the frame is covered with boards pped to shed rain. In severe climates, sash should be used, then

mats may be placed on the sash and covered with lapped board The coverings can be blocked up on warm days to secure ventilatio

Trenching has long been a popular method for storing this cro and is especially adapted to holding the green varieties. A trench 1 inches wide is dug in the garden or the field where the crop is grow It should be deep enough to receive the plants so that the tops wi not protrude more than a few inches above the ground. Trenchir in most northern sections may begin any time after the middle October. The plants are lifted with short roots and the adherir soil and set close together in the trench. If possible, they should b dry at the time of handling.

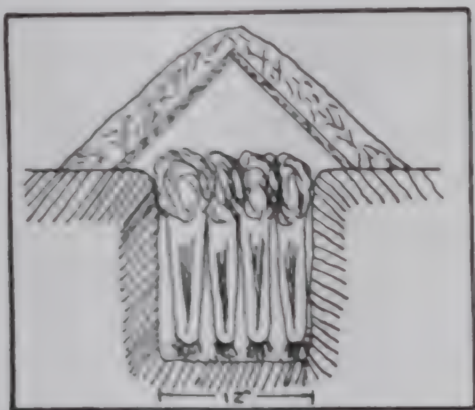


FIG. 94.—Celery stored in trench and covered, for cold weather, with two 12-inch boards in A-form and several inches of litter.

The boards which have been used for blanching are nailed to gether in A-form and placed over the trenched plants, Fig. 94. the weather is warm after the plants have been trenched, blocks stones should be placed under the edges of the boards to admit ai When the nights become cold and some freezing occurs, a light fu row of soil is thrown along the base of the boards. Later the boar and soil are covered with straw, increasing the depth as necessar Ventilation may still be provided at the ends of the A's. Trenchir is most generally used when the crop is to be sold rather early in t winter.

The storing of celery in large pits, or temporary houses, is t common method around Boston. The ridge is usually of 2 by 6 or by 8 lumber, and is 6 or 8 feet high; the purlins are of 2 by 4 2 by 6, and the walls of plank or earth are 3 or 4 feet high. T width is adjusted for two lengths of the blanching boards which a used to make the roof, and usually is 20 to 25 feet. The length

determined by the quantity to be stored. When construction is begun and the width has been determined, 6 or 8 inches of soil are taken off and banked around the sides.

The first row of celery is placed across one end and against the wall of earth or planks. A hoe is used to work earth against and around the roots. Other rows are placed in similar manner with the plants touching in the rows and very slight space between rows—just enough to prevent heating or sweating. Unless care is taken to place the plants erect, they will grow crooked and prove less desirable for market. At distances of 10 or 15 feet, a board, staked lightly in position, is placed against the last row; after leaving a path about a foot wide another board is staked on edge to hold the first row of the next "bay." The paths are useful for inspecting the pit and also aid the circulation of air. As the filling proceeds boards are placed on the overhead frame. At the beginning of cold weather, marsh hay or other litter is spread over the boards with every tenth board left uncovered to serve as a ventilator whenever outside conditions permit. Additional litter is kept at hand to be applied if there should be a sudden and extreme drop in temperature. Covering is added as required until it is about a foot deep, after having been packed by rain and snow. Ventilation is controlled to keep temperatures as low as possible without freezing.

With skilful and frequent attention and relatively uniform cold weather, celery may be kept in good condition in pits or even in trenches until January or later. The manager of either pits or trenches, however, is quite helpless when prolonged warm weather occurs and results in blackening and decay of the foliage with consequent great reduction in marketability. In fact, serious spoilage will occur in a few weeks or even less of warm, rainy weather. Probably as much celery is spoiled by too much covering and too little ventilation as is lost by freezing.

Permanent celery storage pits or houses were common at one time in certain districts. They are managed as described for temporary pits and also are susceptible to heavy losses from spoilage in warm winters.

On account of spoilage and less attractive appearance, as compared with fresh southern or western celery, common storage of celery is declining in popularity and commercial cold storage is being used more extensively; in fact, it is employed almost exclusively by the larger producers. Cold storage provides complete control of temperature and humidity, requires less labor, and the crop may be stored as early in the fall as it is ready without the risk of severe freezing which must be taken with other methods in an effort to shorten the period of common storage. In addition, less labor is required and the crop may be removed from

cold storage and marketed regardless of the weather. It is cus ary to maintain the cold storage for celery at 32° F., or a tr lower and at a relative humidity between 95 and 98 per cent. H temperatures are favorable for the development of disease an cay. Fluctuating temperatures result in much condensatio moisture and excessive humidity. Wilting occurs if the humid too low. Because plants, even in cold storage, continue to be s what active, heat and products of respiration are liberated naturally follows that relatively small, narrow crates, piled ample stripping and spacing to assure circulation of air, are n sary to avoid much spoilage. See Figure 76.

Returns.—Small areas of intensively grown celery some produce at the rate of $2,000 gross returns an acre. While th extremely unusual, it shows the great possibilities of this crop both prices and yields are high. Market gardeners who irrigate quently secure gross incomes of $1,000 an acre. But total rec of $800 an acre are considered excellent, while the average is a $450 an acre. The cost of producing and marketing an ac celery varies greatly, but it is seldom less than $200 and ma two or three times that amount with the most intensive metho high-priced land.

Insects.—In comparison with most vegetables celery is paratively free from the attacks of insects. Sometimes, usually in the season, the corn earworm, celery leaf tier, and other c pillars become sufficiently numerous to cause serious da Rotenone or pyrethrum insecticides are effective.

The tarnished plant bug sucks the juices causing the ch teristic "black joint" where the leaves join the petioles, or "b heart" or "blackheart" in the center of the plant. Serious l often occur where celery adjoins favorable overwintering places the insects. The Michigan recommendation (Circular Bulletin is repeated applications of sulphur-pyrethrum dust at the ra about 15 pounds to the acre per application. Two application the recommended rate, 30 minutes apart, are necessary for con The material should contain about 30 per cent of finely gr pyrethrum powder. Pyrethrum sprays containing a spreader ma used according to the manufacturer's directions, making two a cations 30 minutes apart. The same treatments will contro celery leaf tier. Rotenone is relatively ineffective with these ins

The following recommendations are quoted from Cornell E sion Bulletin 206:

"Recent experiments indicate that the injury can be lessened to a con able extent by spraying or dusting with superfine sulfur and hydrated The dust should contain 50 parts of sulfur (300 mesh) and 50 parts of hy lime. For the spray 25 pounds of sulfur and 15 pounds of lime are us

100 gallons of the mixture. Unless wettable or flotation sulfur is used it is sary to add 2 to 4 pounds of dried skimmilk to each 100 gallons to make sulfur mix with the water. The dried milk should be put in the water and the sulfur and the lime washed through a screen into the tank with the y gun. The dust is cheaper than the spray and is as effective.

"The first application should be made on early celery the latter part of June, n the tarnished plant bugs begin to migrate into the field. The treatment ld be repeated at weekly intervals until about a week before harvesting. late celery the first application should be made about six weeks after the ts have been set out and should be repeated at weekly intervals.

"This schedule should be modified, depending on the abundance of the bugs. ome cases it is not necessary to make any application until late in the season. etimes early applications are needed and the late ones are unnecessary.

"If dust is used, 75 pounds to the acre is needed for wide culture and 150 nds for close. If spray is used, 100 gallons to the acre is needed for wide ure and 200 gallons for close.

"Where it is desirable to treat celery for blight as well as for plant bug, the owing dust formula may be used:

Superfine sulfur	44 pounds
Hydrated lime	44 pounds
Monohydrated copper sulfate	12 pounds

"If blight is to be controlled, the dust must be applied while the plants are with dew.

"If spray is used, the following formula is followed:

Superfine sulfur	25 pounds
Hydrated lime	75 pounds
Copper sulfate	3 pounds
Water to make	100 gallons"

Diseases.—Blights are by far the most serious diseases of cel-. Losses of 50 to 100 per cent are not exceptional when preven- measures are neglected.

Early blight (caused by *Cercospora apii*) usually first attacks tips or margins of the leaves and appears as tiny yellow spots ch enlarge rapidly into irregular blotches of gray color. This ase generally becomes most active in midsummer.

Late blight (caused by *Septoria petroselini* var. *apii*) usually cks the lower outer leaves first, appears as small spots which unite into irregular blotches containing dark pin-head fruiting ies, and is likely to become most destructive in September and ober. It often appears in the seed bed, however, and must be bated from the beginning. It is most destructive, affects the en- above-ground portions of the plant and, in severe cases, often re- s in complete ruin of the crop, either in the field or in storage.

Bacterial blight (caused by *Bacterium apii*) is commonly less ructive than the others and appears as reddish or rusty-brown s of small size, but without the black-headed fruiting bodies racteristic of the late blight.

Fortunately, foliage diseases of celery may be controlled by the same measures. Production of clean plants is the first step. Infection in the plant bed often passes unnoticed, but it is a prolific source of dissemination that frequently leads to a general and apparently sudden epidemic in the field. Rotation of the plant bed area or the provision of new or sterilized soil is necessary to assure a clean place for the plants to grow. Because late blight may be borne in the seed, disinfection is advisable as described (p. 22). New seed may be kept 2 or 3 years before planting, during which time the organism usually dies. Crowding, inadequate ventilation, watering late in the day, and holding plants too long in the plant beds all aid development and dissemination of blights.

Systematic and regular applications of copper fungicides are essential nearly everywhere that celery is grown and should begin with the weekly treatments in the plant beds. Standard materials are bordeaux mixture 3-4-50 in the plant bed, and 4-4-50 or 5-5-50 in the field or 20-80 copper lime dust in either. A 30-70 dust may be preferred for difficult conditions. The dust must be applied late in the evening or early in the morning and is ineffective when applied to dry plants. Other copper-bearing fungicides (p. 171) are useful under some conditions to reduce the noticeable residue.

In general high-pressure spraying, with a pressure of 200 pounds or more, with 3 nozzles to the row, and applying 150 to 250 gallons to the acre at an application, is most economical and effective. Dusting at the time indicated also is effective and the lighter weight equipment is more easily operated in wet weather when the wheels of heavy sprayers cut deeply into the soil. Intervals of a week to 10 days are normal but more frequent applications may be required to check an epidemic. Spraying and dusting should be considered as preventive measures designed to keep the surface of the plants covered with a protective armor, and are especially requisite before and during damp or showery weather. Thorough application is absolutely essential. All parts of the plant above ground must be reached and covered.

Because blights live on dead plants and refuse, thorough cleaning up of the plant beds and clean plowing with 3-year or longer rotations in the field are advisable.

Bacterial rots are troublesome in some districts, especially where methods are very intensive and rotation is not practiced. Clean or sterilized seed beds, burning or prompt plowing of diseased refuse, and rotations of 2 or 3 years are practical means of prevention.

Blackheart is physiological in nature and may be caused by insects, fluctuations in moisture, nutritional deficiencies or excesses, and extremely high temperatures. It is usually the ma

ture or nearly mature plants that are attacked; hence, harvesting should be prompt in hot weather.

Yellows is caused by a fungus of the Fusarium group. It may survive many years in the soil and is most troublesome in the warmer areas. Affected plants are yellow, stunted, bitter in flavor, and stems cut lengthwise will show yellowish streaks. Michigan Golden is a desirable resistant variety.

LETTUCE (*Lactuca sativa*)

History.—This species, which has never been found in the wild state, is thought to be a modification of *Lactuca scariola,* which is indigenous to parts of Europe, Asia, and Africa. The Greeks and the Romans used lettuce as a salad, and it is probable that the ancients were familiar with its cultivation.

Importance.—Lettuce is the most important salad crop. In recent years its use has increased phenomenally. Practically every housekeeper includes lettuce in the diet, and it is used universally as the base for salads. Market gardeners regard it as one of their most profitable crops, and the truck farmers of the South and West grow it on a large scale for northern and eastern markets. The areas devoted to lettuce are especially large in California, New York, and New Jersey. As a forcing crop, both in frames and in greenhouses, it occupies a place of importance. Lettuce may be found on the markets throughout the year.

Climatic requirements.—Lettuce is a cool weather plant. It stands cold much better than heat, and most varieties produce seed shoots prematurely when an attempt is made to grow them in midsummer. The markets are supplied by various regions which furnish the best conditions as the season advances and to a small extent by the use of glass during the winter. When properly hardened the young plants will survive even lower temperatures than cabbage plants, but the mature crop is quite easily damaged by freezing. Lettuce is grown all summer in parts of the North, but extensive commercial production is confined chiefly to the spring, late summer, and fall seasons. In the South and West lettuce is grown mostly as fall, winter, and spring crops, while summer production is carried on at high altitudes in the Mountain States.

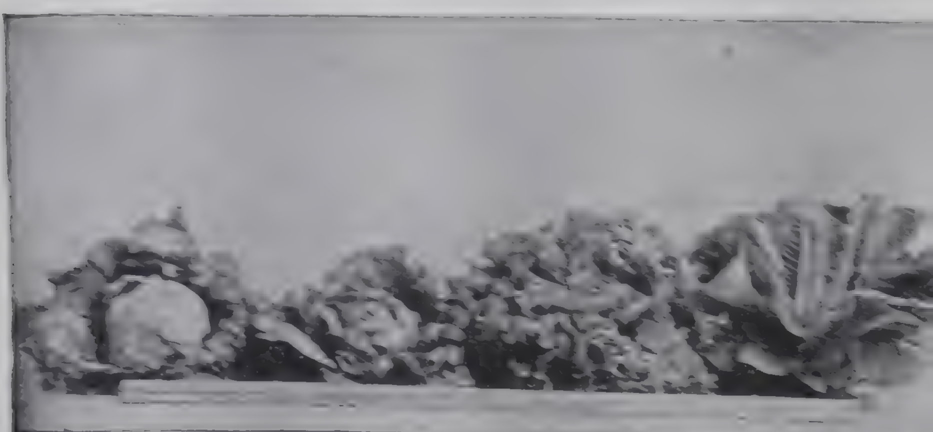
Soil.—Sandy loams are preferable for the early crop, although lettuce is grown successfully on many types of soil. A very large proportion of the late summer and fall crops in the North is produced on muck soils. Silt and clay loams also are used extensively for growing lettuce and even may be preferable during the warmer parts of the growing season. The heavier types must be supplied with sufficient organic matter to prevent their becoming compact.

Varieties of lettuce may be divided into four typical cla[sses] and differ greatly in form, texture, color, and in adaptation to climate, and seasons within each class:

Loose leaf varieties are characterized by rather sprea[ding] habit, clustered or bunched arrangement of leaves, little or no o[ver]lapping of the inner leaves, and more or less frilled foliage. *Gr[and] Rapids*, the most important variety, is produced extensively u[nder] glass, especially in the Middle West; and is grown widely outd[oors] as an early spring crop. *Black-seeded Simpson* endures hot wea[ther] better and produces more tender leaves. It is very desirable for [the] home garden at all seasons and is used by market gardeners [and] roadside marketers as the best late spring and summer variety [of] leaf lettuce. The foliage is too tender and perishable to make [the] variety suitable for the general wholesale trade.

Crisp head varieties are of cabbage-heading habit with [the] central leaves much overlapped; the foliage is crisp or bri[ttle], coarse veined and large ribbed with the inner portions slig[htly] translucent white. *New York* is called "Iceberg" by the pro[duce] trade. Many strains have been developed to adapt this most [pop]ular lettuce to different environmental conditions. Suitable str[ains] should be specified, as *Imperial 44*, *New York No. 515* or *New Y[ork] No. 12* in the northeastern states. Under such conditions the [crop] must be grown very early in most places, usually from plants sta[rted] under glass, to assure a high percentage of solid heads. It is [not] generally adapted to warm humid weather or to muck soils, alth[ough] suitable strains may be developed.

Butter head varieties also are of cabbage-heading habit with comparatively smooth, finely-veined leaves of soft tex[ture] and buttery flavor. *White Boston* and *Big Boston*, the la[...]



The Pennsylvania State C[...]

FIG. [illegible].—Types of lettuce: Crisphead, Butterhead, Leaf, and Cos or Romain[e].

ghtly tinged with reddish brown, are the most popular varieties r the late summer and fall crops on muck soils. White Boston is own extensively in the spring in some sections. *Salamander*, also lled *Black Seeded Tennisball*, is a more dependable header in arm weather and is planted extensively as a spring and summer op by growers who have a demand for butter head lettuce. *May ing* is of similar type but earlier and smaller. It is the standard utter head lettuce for greenhouse culture and, to a limited extent, r very early planting under most intensive outdoor conditions.

Cos lettuces or Romaine, are distinguished by upright habit, ong heads, and spatulate leaves. The leaves, which have large, r little ribs, are crisp and of high quality. Cos lettuce is in good demand in some cities and usually is grown early in the spring or durng the cool season in the fall, as it seeds quickly in hot weather. *White Paris* or *Trianon* is the standard variety.

Seed.—Most of the lettuce seed used in this country is produced n California. A few growers produce their own supply by selecting nd saving a few of the most desirable plants. In some cases the verlapping leaves of heading varieties should be slit crosswise. Because the seed matures progressively the harvest must be timed to void too much immaturity and also loss by shattering. The amount f loss is reduced by cutting the plants in the morning, while still omewhat damp and placing the stalks on sheets of muslin until ry enough to thresh. Screening and winnowing complete the rocess.

Starting early plants.—A popular and satisfactory method is to w in hotbeds or greenhouses, and to transplant, preferably into ats, which may be kept in cold frames until the plants are set in e open ground. The seed should be sown 8 to 10 weeks before e proper date for field planting, the plants being handled in the me manner as cabbage. If space permits, it is an advantage to ant 2x2 inches apart in the flats rather than closer. To prevent indling, the seedlings should be pricked out in about two weeks om sowing. The soil for sowing and transplanting should abound well decomposed matter. Pure muck is probably the best meum, but, if this is not available, a compost of about two parts of od soil, one of sand, and one of rotten manure will provide exlent conditions. Mice are very fond of the seeds and tender seedgs. They are poisoned by grain soaked with a solution of strychie. The plants should be hardened before setting in the field en there is danger of hard freezing.

Another method is to sow thinly in the hotbed or the cold frame o 6 weeks before the ground can be worked in the spring and set plants in the open without previous transplanting. This plan

does not result in strong plants unless the rate of sowing and conditions of growth are managed with great skill.

Fertilizing.—In preparing the soil for lettuce the grower should bear in mind that rapid, continuous growth is essential to high quality and large yields. An abundance of organic matter is particularly important for lettuce, both to assure great moisture-holding capacity and to maintain the friable condition which is necessary to encourage development of the naturally limited root system. Stable manures or green manures should be used very freely.

General fertilizer recommendations for upland soils are 4-12-4 with manure and 5-10-5 without manure or legumes. Usual rates are 1000 to 2000 pounds to the acre. It is considered that tip burn is increased by a high ratio of potash and by top-dressing with nitrogen near the time of maturity. For the fall crop 1000 to 2000 pounds of superphosphate alone often may be applied before planting. Then nitrogen is used when warm weather is over. To some extent fall lettuce may be considered as a catch crop when it follows heavily fertilized early vegetables.

For the fertilization of lettuce on muck soils, Underwood and Knott, in Cornell Extension Bulletin 230, make the following recommendations:

> "Potash appears to be more necessary for lettuce on new muck than on old; nitrogen more on older muck than on new. Usually from 750 to 1000 pounds of a 5-10-5 fertilizer will be satisfactory. If the lettuce follows a crop which was heavily fertilized the year before, less than this quantity may do. For lettuce on newly cleared muck of a woody nature, from 750 to 1000 pounds of the 0-10-10 analysis would be suitable. A light side dressing of nitrate of soda might be needed on an early crop in a cool, wet season. The 3-12-6 at 500 to 750 pounds per acre is suggested for late sowings on old muck, made between June 15 and July 15."

The preplanting application of fertilizer is broadcast and harrowed in thoroughly. After the plants are well established one or two dressings with nitrogen often increase the rate of growth, especially in early spring. Nitrate of soda at the rate of 150 or 200 pounds to the acre is used most commonly. It may be broadcast just before rain or sprinkler irrigation, or distributed between the rows preceding cultivation.

Lettuce will not thrive on acid soils, but excessive liming generally may be unfavorable for the best heading of at least some varieties. Reactions of about pH 6 generally are suitable, although pH 5.5 is permissible on soils well supplied with organic matter, and pH 6.5 may be optimum on many mineral soils.

Setting plants.—The soil should be prepared thoroughly to a good depth. Rows are marked and may be cross-marked to permit wheel hoeing both ways while the plants are small. Leaf and Cos

varieties usually are spaced 8 to 12 inches in rows about 12 inches apart. Heading varieties require more space—12 to 18 inches apart —to permit the development of large, firm heads.

Sometimes lettuce is planted in beds, perhaps 8 by 8 to 10 by 10 for leaf varieties and 14 by 14 to 18 by 18 for heading varieties, with space for walks or dead furrows for drainage between the beds.

Planting of two rows on narrow ridges is the standard method with furrow irrigation and is practiced to some extent with the early spring crop to accelerate drainage, aeration, and warming of the soil.

Plants that have been hardened well may be set at least as early as cabbage. To assure the highest survival and the earliest crop, the plants should be removed from the plantbed or flats with the least possible disturbance of the roots, and, preferably, with a ball of root-filled soil attached to each. Thorough watering several hours in advance and lifting the plant with a tool or by hand, rather than pulling, are essential for best results.

Large, transplanted plants can be set in small furrows. Smaller plants usually are set with a dibble and in the space alongside the mark if the latter is deep. Deep planting must be avoided. It causes misshaped heads and favors decay of the lower leaves which is a common cause of serious loss.

Lettuce plants often are set as intercrops between cabbage plants in the rows, or between the rows of many other vegetables.

Sowing in the field.—The first sowing usually is made as early as the soil can be put into condition; in fact, some growers sow in late winter on "hard ground," that is, frozen ground, which had been fitted the preceding fall. Successive sowings of suitable varieties are required, if prolonged or continuous supply is desired. The last sowing in most northern sections is made between the middle of July and the first of August, with the actual dates variable according to varieties, locality, and cultural conditions.

Rates of seeding should be regulated according to the vitality of the seed and probable conditions for germination. Too thick stands are expensive to thin, and inadequate stands limit returns. In moist seasons and with irrigation, light covering is desirable. Under dry conditions a covering of one-fourth to one-half an inch is not too much. Single-row drills or twin drills are used for the smaller plantings, and multiple-row seeders for large areas. Rows are from 10 to 18 inches apart, depending on the variety and conditions. About 3 pounds of seed are used to the acre.

Thinning of sown lettuce is necessary to provide adequate space for the development of each plant, thereby assuring uniform size and maturity. The operation should be completed promptly; delay will interfere with proper development. Spacings are 8 to 18 inches

depending on the variety. A labor-saving practice is to "block" i tiny clumps of plants by cutting through the row with a sharp nearly the width of the desired spacing, or, on even land, a dou wheel hoe with the blades an inch apart may be run across the ro By using the fingers or a small blade weeder, the plants in e clump are reduced to one. Doubles must be eliminated as they not produce first-grade marketable heads.

Cultivation.—One or two wheel hoeings of transplanted lett and two or three wheel hoeings of sown lettuce, as well as one or hand hoeings of either, are necessary, as a rule, to control weeds keep the surface loose. Injury to the root system by deep worki damage to the foliage, and hilling are to be avoided. The push or scuffle hoe is very useful in easily worked soils.

Irrigation.—Most lettuce growers on upland soils, and many muck, consider irrigation indispensable. If the soil is dry at tra planting time, it is irrigated several hours or a day previous to ting the plants. Even on moist soil, light sprinkling is benefi immediately after planting and on bright days until the plants come established. Irrigation also is of great advantage in caus the seeds to germinate promptly and certainly in droughty weat which often occurs when the fall crop is to be started. Libe uniform supplies of soil moisture are necessary for continuous, ra growth and for large yields of crisp, high-quality lettuce.

Overwatering favors the development of diseases and, at time of heading, may cause soft growth and lack of firmness. Ab an inch of water every 5 to 10 days, depending upon the nature the soil and the rate of evaporation, is needed for best results. W tering during the day or night is customary, although some grow prefer to water in the evening after heading begins to avoid any p sibility of scalding or burning.

Protection from freezing.—Lettuce that is almost ready market often is injured by heavy frosts or light freezes. Sprink irrigation sometimes provides successful protection, although a m common practice is to cover the plants with hay or straw. In tensive operations muslin or burlap covers, supported by narr strips, are used to a limited extent.

Harvesting of leaf lettuce may begin as soon as the plants re acceptable and profitable size, and should be completed before leaves become tough and bitter or seed stalks become noticeable.

Timeliness in harvesting head lettuce often is of utmost imp tance. Good judgment is required to harvest the heads just wh they have made the best development that weather conditions permit. Delay in hot weather, either to await better markets or secure greater firmness, may result in serious depreciation of qual or even in total loss of the crop.

By cutting in the morning during hot weather the plants are risp, and the leaves are not flabby or wilted. If ice is not to be laced in the packages, however, cutting should be delayed until the ew has evaporated, if the crop is to be shipped. Great care should e exercised to prevent wilting or heating in the field or the packing ouse and in transit, and to make certain that the lettuce will reach he destination in attractive, crisp condition.

Proper trimming of damaged and diseased leaves and careful rading help to secure profitable sale. Washing and then packing vith crushed ice in paper-lined containers is standard practice for ong-distance shipment and deserves greater consideration by grow-rs for nearby markets. Refrigerator cars generally are employed or shipment by rail and ice often is used aboard trucks. Good let-uce keeps about a month in properly regulated cold storage (p. 205).

Yields and returns.—An acre of well grown lettuce should yield t least 20,000 heads, but greater or smaller numbers often are pro-uced. Small areas near local markets sometimes return $1,000 ross income an acre. Returns are rarely half as high in shipping. Prices vary greatly from year to year, or at different seasons of the ame year.

Insects.—Cut worms, plant lice, and cabbage loopers sometimes ause injury and may be combated with poison bran mash, nicotine, nd rotenone or pyrethrum, respectively, as described in Chapter X.

Diseases.—Tip-Burn is a physiological disease characterized by rowning or blackening of the margins of the leaves. The injury ften develops to a serious extent on lettuce maturing during hot eather, particularly following damp, warm periods. Balanced and oderate fertilization, decreased irrigation as maturity approaches, nd perhaps root pruning as the heads attain marketable stage are f some value as preventive measures, but in no sense do they as-ure control when conditions become unusually favorable for the isease. Tip-burn seldom causes material loss during cool weather. he Big Boston variety is especially susceptible.

Lettuce Drop (caused by *Sclerotinia*) is characterized by very pid wilting, rotting, and collapse of the plant. The disease often especially serious in greenhouses, hotbeds, and cold frames and is ontrolled by disinfection of the soil. In the open, disinfection is o expensive except for limited, intensively cropped areas. The me fungi attack celery, carrots, cabbage, and many other vege-bles. Long rotations that include sweet corn, solanaceous crops, icurbits, bulb crops, or tuber crops are recommended.

Bottom-Rot (caused by *Rhizoctonia solani*) first attacks the aves that rest on the soil and eventually may work up into the ad. It is characteristic that the leaf areas between midribs are tted first, and that the main stem of the plant escapes destruction.

The fungus is most destructive in damp weather on low-growing spreading plants, and develops rapidly after harvest on the portion of the crop left in the field. Removal of diseased plants or refuse prompt and thorough plowing, rotation as suggested under Lettuc Drop, production of clean plants, adequate spacing, and clean cul ture are helpful preventives. Organic mercury dusts, such as Dubay 730 or Improved Ceresan, have secured a satisfactory degree o control when blown under the plants at the rate of 25 or 30 pound to the acre two or three weeks before maturity. Relatively erec varieties or strains, such as New York No. 515, are less damage by bottom rot than are the more spreading types.

Downy-Mildew (caused by *Bremia lactucae*) is likely to be come serious only on lettuce grown under glass, where it is controlle principally by maintenance of structures and management of ven tilation to avoid condensation and high humidity. It is favored b temperatures below normal and checked by temperatures above nor mal for the greenhouse lettuce crop. In the field, rotation and elim ination of wild lettuce are advisable.

Gray Mold-Rot (caused by *Botrytis*) seldom is destructive i the open but may be serious under glass. Sufficient ventilation t avoid condensation, and comparatively low night temperatures ar recommended.

Yellows and **Mosaic** are virus diseases. The former is foun on many cultivated plants and weeds and is transmitted by leaf hop pers; the latter is borne on the seed and is carried from plant t plant by aphids and other sucking insects. Control of insects i helpful and, in case of Mosaic, production of disease-free seed is possibility.

PARSLEY (*Petroselinum hortense*)

Parsley is attractive for garnishing and it is valued also fo salads and as a seasoning for soups and meats. It is a native of th south of Europe and was used by the ancient Greeks and Romans The crop is of minor commercial importance. It is seldom plante extensively, but small areas are grown by practically every hom and market gardener.

Varieties.—Plain-leafed, fern-leafed, and curled-leaf varietie are available. *Moss Curled*, *Emerald*, and *Paramount* are favorite *Hamburg* is a turnip-rooted variety that is discussed in Chapte XVIII, Root Vegetables (p. 358).

Culture.—As parsley seeds germinate very slowly, the plan often are started under glass, and may be transplanted once befo setting in the open. They are hardy and may be taken to the ope ground almost as early as cabbage. It is customary also to so outdoors early in the spring, or as late as June for fall sale.

The rows should be about 14 inches apart or more and the plants 6 to 10 inches apart in the row. The outer leaves may be used as soon as they are large enough, and they can be gathered as they develop during the entire season. Parsley will thrive in any moist, fertile soil. Liberal fertilization is especially valuable in securing rapid, tender growth. The leaves are tied together in small bunches for marketing. Crushed ice should be used in packages. By protecting the plants in cold frames, a supply of parsley throughout the winter is assured.

ENDIVE (*Cichorium Endiva*)

Importance.—This plant, which is probably native of East India, was used as a salad and potherb by the ancient Greeks. It is an annual, and, as it is hardy to frost, it is grown mainly as a late fall or early winter crop and used principally for salad purposes. The cut, curled, and frilled leaves are very decorative and frequently are used for garnishing and for flavoring soups; they are also cooked as greens.

Varieties.—There are two general classes, namely, the curled or fringe-leaved and the broad-leaved varieties. The former are highly ornamental and more largely grown. *Green Curled Ruffic*, large green-ribbed; *Green Curled Pancalier*, large pink-ribbed; and *White Curled*, smaller, are of the first class. *Broad-leaved, Fullheart Batavian*, or *Escarole* represents the second class, which is used mainly unblanched in stews and soups.

Culture.—The rich, moist soil and fertilization adapted to lettuce will produce a good crop of endive. Rapid growth is important to secure tender, succulent leaves.

Although grown mainly for fall and early winter markets, an early summer crop may be produced by starting the plants under glass or by sowing in the open as soon as the ground can be prepared. For the fall crop the seed should be sown in July or August, depending upon climatic conditions. Growth is most satisfactory during the cool fall weather. The seedlings may be started in specially prepared beds, and transplanted when of the proper size, or the seed may be sown where the plants are to mature. Whichever method is used, 1 foot apart each way provides sufficient space for full development of the plants. Some growers prefer to thin to 6 to 10 inches in 15 or 18-inch rows.

Blanching.—Unless the crop is wanted for soups or greens it should be blanched to reduce the bitterness, to render the leaves more tender, and to make the vegetable more attractive in appearance.

Blanching requires 10 to 20 days or longer in cool weather. Any means which will exclude light from the central leaves and, if

possible, keep the hearts dry to prevent rotting will be effective. The leaves should always be dry when blanching is started. The plants should not be blanched faster than they are to be used, because of the danger of the white tender leaves decaying when fully blanched. Under some conditions sufficient blanching may be secured by the crowding that occurs with close planting.

The most common method employed is to tie the tops together with raffia, coarse twine, or rubber bands. Covering with boards, tile, pots or other devices will serve the purpose. Leaves or straw may be thrown over the plants late in the fall if it is desired to keep them in the field when the weather may become severe. Some growers lift the plants with a little earth clinging to the roots and reset them close together in cool cellars, pits, or cold frames, shading them when blanching is desired. Endive may be preserved in this manner until midwinter.

CHICORY *(Cichorium Intybus)*

Character and uses.—Chicory is a well-known European vegetable. It is used to some extent in the large American cities. To a very limited extent, the roots are cooked, and, when roasted, are used also as a substitute for coffee. The leaves may be cooked like dandelion. When well blanched they are prized for salad purposes. The most popular form of chicory is produced by forcing the lifted roots of the *Witloof* variety in trenches, the product being known as Witloof or French endive.

Field culture is essentially the same as for parsnips.

Forcing.—Late in the fall but before the ground freezes, the roots are dug, the tops are cut to within an inch of the crown, and the roots are stored as are other root crops. Before the roots are placed for forcing they are sorted into about four lengths, and the slender tips are cut in order to make all in a grade about the same length. Thus all the crowns will be on a level when the roots are placed. Roots that are not too large, over 1¼ or 1½ inches in diameter, are preferred for forcing as larger roots produce many double heads.

Forcing may take place under greenhouse benches, in cellars, or in outdoor trenches. In trenches heat is supplied by a final covering of two feet of hot horse manure extending about two feet on either side of the trench. Temperatures of 50 to 60 degrees are desirable.

The roots are placed in an upright position on a few inches of sand so close together that they almost touch. Sand or fine soil is sifted between the roots to surround them completely, and about 6 or 8 inches of the same material, or of sawdust, are placed over the

rowns. This is followed by thorough soaking and then additional watering as required to maintain moisture. When tips appear at the surface of the covering, the heads are harvested by severing the rowns so that the shoots remain attached.

CRESS

The piquant leaves of cress are used in salads and for garnishing. Three common forms are in cultivation. They belong to different genera, but all are members of the *Cruciferae* or mustard family.

Water cress (*Roripa Nasturtium aquaticum*) is a hardy, perennial, aquatic plant popular on all city markets. It thrives best in shallow, running water which must be pure and clean. Water cress also may be grown in moist or wet, shady places, but springs and brooks are preferable. The lime requirement is relatively high. With irrigation it may be grown in all soils, although as a commercial enterprise, success is much more certain with facilities that simulate natural conditions. It is readily propagated by scattering the small seeds or by planting short pieces of the stems 5 to 8 inches apart each way.

Garden cress or Pepper grass (*Lepidium sativum*), a popular European salad plant, is grown to a limited extent in the United States. It is an annual, one of the best early salad plants and is easily grown in any good garden loam. Moist, very fertile soils are preferable to encourage rapid growth and the production of crisp, tender foliage. With favorable cultural conditions the leaves will be large enough for use in four weeks from sowing. Sow thickly in shallow drills about a foot apart. Conserve moisture by frequent tillage and water artificially, if necessary. Garden cress is a spring and fall crop and does not thrive in mid-summer.

Upland cress (*Barbarea vulgaris* and *B. praecox*) is the least important of the three forms. It is a native of a large part of the United States, but is not cultivated to any great extent. It is hardy and does best as a fall or winter crop. The seed remains in the ground all winter and germinates in the spring. Cultural directions given for garden cress apply equally well to upland cress.

CORN SALAD (*Valerianella Locusta* var. *olitoria*)

Characteristics and uses.—This is an annual plant which is popular in Europe where it grows wild in the corn (grain). It finds limited sale in this country. The leaves, which have a mild flavor, are valued for salad purposes and greens, and the curly varieties for garnishing. As the plants are sensitive to heat, they are grown as a fall or spring crop. They are hardy and may be wintered in the

milder sections by protecting in cold frames, or with mulches whe the winters are not too severe. Although the plants attain a heigl of nearly 2 feet, the young leaves are tender and delicious. Tw crops may be gathered from the same plants in cool seasons.

Culture.—The soil should be fertile and well supplied with nitro gen. For the spring crop, seed is sown in the open as soon as th ground can be prepared or in the fall as for overwintering spinac The fall crop is sown in August. The seed should be sown thinl in shallow drills, 12 inches apart, and the plants thinned to 6 inche Irrigation is of great advantage in growing this crop. The plan are ready for use in 40 to 50 days, and the whole plant is cut.

FLORENCE FENNEL or FINNOCHIO (*Foeniculum vulgare*

This is miscalled "Anise" by the produce trade.* It is used as salad vegetable, for flavoring, or as a potherb. The bulb-like po tion formed by the enlarged basal section of the leaf-stalk is value for its sweet anise-like flavor and celery-like crispness.

Culture.—Florence fennel is grown most successfully as a sprin and fall crop; the culture suggested for the larger growing varieti of lettuce is suitable. The bases may be hilled to blanch and th crop is harvested before flower-stalks are formed.

CARDOON (*Cynara Cardunculus*)

This cool season salad crop is a close relative of the globe art choke. The plant is a perennial but the crop is produced as an a nual. The edible part is the blanched leaf-stalk as in the case celery. Plants may be started under glass or the seed can be sow outdoors in the North during April or May. Transplant or thin t 18 or 20-inch spacings in rows 3 or 4 feet apart. Blanching require several weeks and the procedure is similar to the blanching of celer The plants, however, are larger and it may be most convenient t draw the leaves together, wrap with paper or burlap, and tie. I harvesting cut below the crown and remove the outside parts t secure the blanched heart. Cardoon often is cooked in the sam manner as asparagus.

* Anise is a common garden herb.

XV

TOMATOES, PEPPERS, AND EGGPLANT

THE botanical family *Solanaceae* includes four important vegetables. The potato differs from the others in propagation, in cultural requirements, and in the form of the edible portion, which is an underground stem. It is discussed in Chapter XXI.

The others—tomato, pepper, and eggplant—are similar. The fleshy edible parts are considered, botanically, as fruits. All are tender, warm-season crops. As a rule the seed is sown under glass, to secure an earlier and longer fruitful season, and plants are set in the open at the beginning of the frost-free period. Growth and production continue until arrested by frost, disease, or other unfavorable conditions.

Tobacco, petunia, belladonna, nightshade, horse nettle, ground cherry, jimson weed, bitter-sweet, and other common plants also belong to the *Solanaceae* and may serve as hosts to many of the diseases and insects that attack the solanaceous vegetables.

TOMATO *(Lycopersicon esculentum var. commune)*

History.—The tomato is of tropical American origin and it probably was improved beyond its wild state when found by early adventurers. It was grown and eaten by the aborigines and called tomato from the Aztec Xitomate, but apparently was of small importance. In the Sixteenth Century the tomato was called "pomo d'oro" in Italy and "love apple" in England. Early names indicate that the forms first cultivated in European countries originated in Peru and Mexico. The food value of the tomato first was recognized extensively by the Italians. It is legendary that the tomato was thought to be poisonous and was valued principally as a curiosity and ornament. However, Tracy ("Tomato Culture") asserts that it was grown for culinary use in Virginia in 1781. A Frenchman grew and attempted to sell tomatoes to Philadelphians in 1788 but with poor success. An Italian made a similar effort at Salem, Massachusetts, in 1802. Tomatoes were quoted in the New Orleans market in 1812, and offered by seedsmen as an edible vegetable in 1818. The plant gained rapidly in popularity after 1820, and was a standard vegetable in many sections in 1835. Today the tomato outranks all other vegetables, except the potato crops, in popularity and in value. It is grown universally; in home gardens, in green-

houses, in market gardens, for shipment, for canning. Al
million tons of tomatoes are used annually by the canneri

Climate.—The tomato requires warm weather and p
sunshine for its best development. Prolonged cold, cloudy
or repeated low temperatures without actual freezing check
and may impair permanently the fruiting abilities of the pl
medium amount of rainfall, well distributed throughout th
ing season, is essential for high yields, and a frost-free p
about 150 days is conducive to low cost of production. Nev
the tomato crop is grown successfully under a wide range of
conditions and the most extensive plantings are in milder
the northern states.

Where the warm season is short or a very early crop i
able, seed is sown early and the plants are started under g
fact plants for a large proportion of the total acreage ar
with some sort of protection. As the plants remain tender
be hardened only a little, they should not be planted in t
ground until after danger of injury by frost has practically

Soils.—A deep, fertile, sandy loam with a well-drained
soil provides ideal conditions for the culture of tomatoe
crop, however, is grown successfully on a great variety of s
Sandy soils are especially desirable for the very early crop.
ately heavy soils, however, usually produce larger yields,
subject to drought, and require smaller expenditures for th
tenance of fertility. Much of the cannery crop is grown
of this class. Even clay loams when well supplied with orga
ter are adapted to main-crop or late tomatoes. Large m
holding capacity is essential for satisfactory yields and goo
age is necessary.

For the early crop, location and exposure should be
considered. Protection from north and west winds is a g
vantage and southern slopes favor early maturity.

Taxonomy.—The classification prepared by Bailey is
for the one that follows:

(1) *Lycopersicon pimpinellifolium*.—Plants of this spe
characterized by lack of pubescence, little odor, and weak s
growth. Flowers are borne in two rows on a long raceme gi
to the common name "currant tomato." It is of no comme
portance.

(2) *Lycopersicon esculentum*.—This species is the p
commercial tomatoes, practically all of which belong to th
commune. The plants are hairy, of strong odor, and vig
growth. Other varieties in this class are: *grandifolium*, t
leafed or potato-leafed type; *validum*, the upright or dw
with dense, dark green foliage; *cerasiforme*, the cherry-

ormally two-celled, globular fruits and "standard" foliage;
rme, the pear-like or oblong type with "standard" foliage.
rieties.—The more important varieties of tomatoes may be
d rather arbitrarily under headings named for the oldest or
nown variety in each group. Nearly all markets demand the
ruited red varieties, although a few prefer pink or purple.
rliana group.—*Earliana*, in the recent past, probably was
more extensively by market gardeners than all other early
es combined. Extreme earliness, its chief point of excellence,
ept Earliana among the tomatoes commonly planted. The
are bright red, with a tendency to remain green and to crack
d the stem, more or less flattened, inclined to be irregular, and
r shipping quality. The vines are comparatively lacking in
and usually die early in the season. As strains of this variety
great variation, care should be exercised to procure the best.
on Early, *Canadian* and *Penn State* are well known strains
liana.
nny best group.—*Bonny Best*, *Chalk Jewel*, and *John Baer*
nilar. Certain strains are almost as early as Earliana and of
oderate vigor. Others that have been bred for strong growth
eavy yield are nearly main crop in season and are grown for
nneries in some localities. As commonly offered, it is likely
ohn Baer will be slightly earlier and Chalk Jewel slightly
han Bonny Best. The fruits are red, globular to deep flat-
firm, smooth, of medium size, and ripen early. The plants
sceptible to disease but productive and long-bearing under
ble conditions. Bonny Best types are planted extensively in
ouses and are widely used for training to supports outdoors.
Dawn is a promising newer variety of this class.
rglobe group.—The varieties of this group are resistant to
m wilt and less susceptible than many others to foliage dis-
Break O' Day is early, but not quite as early as Earliana.
uits are globular, orange-red, medium large, and only moder-
irm. The very open, spreading habit of growth and sparse
are conducive to sun-scalding and the development of yel-
color in hot climates. Break O' Day seems poorly adapted
t soils and hot climates but is vigorous, productive, and of
color on well fertilized heavier soils in regions of moderate
rs. *Grothen* is similar but second-early, heavier of foliage,
color, and more suitable for hot climates. *Pritchard* has
escribed as a smaller second-early Marglobe type. Fruits
ght red, deep globular, very solid, and of high quality. *Mar-*
s widely planted by home and market gardeners, truckers,
, and for the canneries. Great resistance to wilt, and to
stent to leaf diseases, has made this variety a favorite. Mar-

globe is relatively less susceptible to blossom-end rot. The v plants are productive over a long period. The fruits a medium-large, and firm. Marglobe is one of the most popu generally adaptable varieties. *Rutgers* has been describe slightly later, flatter, and more vigorous Marglobe type of un well developed inside color and high quality.

Stone group.—*Stone* is a standard late variety that is extensively for canning and market. The fruits are scar flattened, very smooth, and firm. The plants are large, vi and heavily productive. *Greater Baltimore* and *Indiana Ba* are favorites that are a few days earlier than Stone. Wilt re strains of the Baltimore selections and of the late Stone t available of which *Norton* is the best known.

Comet group.—*Comet*, *Carter Sunrise*, *Grand Rapids* and others of the English forcing type produce many-fruited of relatively small tomatoes. These varieties are valued fo habit of certain pollination and for firmness and for perfection fruits. They are grown to a limited extent on supports but th are too small for most American markets. Liberal fertiliz required.

Pink varieties.—*June Pink* has been called Pink E Globe and its selections are medium early and are valued shipping sections of the South. The fruits are purplish-pi dium large, globular, very firm, and smooth. *Gulf State* and *Early Detroit* are more or less similar to Globe but a fe earlier and more flattened. *Cooper Special* is a compactly g "self-topping," crimson-pink, globe-shaped tomato that planted largely for shipping in the so-called mature-green *Beauty* is a flat, medium late pink variety that formerly wa lar with market gardeners. *Oxheart*, a late, heart-shaped bu irregular pink tomato, and *Ponderosa* (*Beefsteak*), a very flat and often irregular tomato, are valued for their unusually interiors with few seeds, mild flavor and low acidity. Th popular with many home gardeners and are grown to a limi tent as specialties by market gardeners.

Miscellaneous varieties.—*Golden Queen* is the standard fruited yellow tomato. Small-fruited tomatoes, that are gro preserving or pickling and for use in salads, include red and kinds in currant, cherry, plum, pear, and peach shapes or siz

The *Ground Cherry* or *Husk Tomato* is not a true toma belongs to the genus *Physalis*.

Seed.—Tomato seed of outstanding excellence in resp genetic factors and freedom from disease is available to t criminating buyer. Many growers, seedsmen, and canneries s ize in its production. Because two ounces of seed will p

nts for an acre it pays to seek and secure the best seed regardless price. Many of the most successful tomato growers save their seed which is an advantage in several respects when intelligently managed. Seed treatment should be practiced (pp. 19, 22,). Hot water is most effective.

Starting early plants.—The proper time to sow depends upon: The facilities available for growing the plants; (2) climatic conditions; (3) purpose of the crop; (4) land available; and (5) market conditions. In most instances the tomatoes that ripen first command highest prices so that the majority of market growers desire to secure their product at the earliest possible date. However, considerable investment in equipment and expenditure of time and money are necessary to grow very early tomato plants.

FIG. 96.—Large sturdy tomato plants are essential for the earliest crop. They may be grown in bands, pots, flats, or by blocking in beds.

The following plans are typical, although there are many others far as details are concerned:

1. Sow thinly, 6 to 8 weeks before field planting, in hotbed or planthouse in rows about 6 inches apart and set in the field without previous transplanting. This plan is not generally used because the plants are often small or spindly and the root system is poorly developed. With expert management, especially where earliness is not important, good results may be obtained.

2. Sow 10 to 12 seeds to the inch of furrow, rows 2 inches apart, to 8 weeks before field planting; transplant 2 or 3 inches apart in or 4 weeks from sowing. This plan is not suitable for the earliest crop but is used extensively for main crop production.

3. Sow about 9 or 10 weeks before field planting; transpl 1½ or 2 inches apart, preferably in the greenhouse; about 3 we later, plant 4x4 to 6x6 inches apart in flats or beds, or in 3 to 5-in paper or earthen pots, or in veneered boxes or berry baskets. T method, with its modifications, is extensively employed to prod the largest and finest plants.

However, equally good plants can be grown with a single sh if the full amount of space is available when the seedlings are f transplanted. Providing ample space for development is more portant than the number of transplantings. In fact, many grow prefer to transplant only once because plants thus produced at eral spacings are subjected to less checking of growth, and start i growth more promptly and vigorously when transferred to the fi

Many of the best growers, especially in New Jersey, pract "blocking" as described (p. 56). It is especially desirable in gr ing large plants for the early crop. Blocking must be comple before the leaves begin to interlace.

A few growers sow 10 to 12 weeks before field planting, make three shifts in flats, beds, or preferably pots, the space or size of the pots being increased each time until the plants stand 6 10 inches apart. When this method is followed, the crown cluster flowering buds usually has blossomed and formed small fruits bef the plants are set in the garden. Ripe tomatoes from plants of t character have been gathered within 6 or 7 weeks from the time planting in the open ground, often soon after July 1 in the Nor A handful of ripe tomatoes at that time may be of more value th a bushel will be late in the summer. On the other hand, the cost producing such widely spaced plants is very great, and tom plants which are set in the field bearing small fruits often exha their resources in maturing the first cluster and fail to make growth necessary to produce a full crop.

Ideas differ concerning the ideal plant, but many expert tom growers strive to produce large, stocky, firm, but not over ha plants bearing the first bud clusters at the time for setting in field. Such plants can be produced with either one or two tra plantings, provided sufficient space is allowed and they are gro at a moderately rapid rate without severe checking. Exposure low temperatures is detrimental. Extreme hardening, characteri by deep purple color, or holding the plants so long that they t yellow and the lower leaves begin to fall, produces woody pla that are most unlikely to make satisfactory growth in the field.

Yellowing from nitrogen exhaustion may be controlled wh necessary by the application of a pound of nitrate of soda to square feet, by very even broadcasting of the crystals or by wa

ng with a solution of 1 ounce to the gallon. Or a nutrient solution may be used. Sprinkle well after the application.

Clipping or pinching off the top shoots to induce stockiness or branching is done to a limited extent, but the practice is considered of little effect in increasing the crop and certainly it is a prolific means of spreading mosaic.

Starting late plants.—In many of the warmer districts where tomatoes are grown for the cannery, the seed is sown in the open and the plants are set in the field when they are 6 to 8 inches tall. In northern sections plants are generally started under glass or protecting muslin or canvas and set in the field with or without previous transplanting. Both practical experience and experiments indicate, however, that relatively early sowing with one transplanting usually increases yields. The truckers and market gardeners of the North often exercise almost as much care in starting late plants as early ones.

Southern grown plants are used to a considerable extent, especially for the cannery crop. When well grown and properly handled such plants often produce excellent yields. Certified plants are available from some producers.

Spraying and dusting in the plant bed.—Young tomato plants, as well as eggplants and peppers, should be sprayed every week or ten days with 2-2-50 or 3-3-50 bordeaux mixture or preferably with one of the newer copper fungicides (p. 171). With bordeaux mixture the last spraying should be completed at least a week before the plants are transplanted into the field to avoid increased transpiration and greater losses in transplanting. Include calcium arsenate. If spraying is inconvenient, 20-80 copper lime dust or an insoluble copper dust (p. 171) containing an arsenical may be used. Thorough application is essential to protect all above-ground parts of the plants including upper and lower surface of the leaves. Damping-off may be retarded. Thus, at minimum outlay of time and material, the plants will be armored against foliage diseases and the certain attacks of flea beetles and other insects that often cause serious damage and loss among newly set plants.

Soil preparation.—Land manured heavily for a cultivated crop the preceding year should be in prime condition for tomatoes. In fact only rotten manure should be applied just before the tomato crop is planted. Fresh manure should be applied in the fall or winter or to the preceding crop. Heavy legume sods and green manures are employed extensively before planting tomatoes. Timely plowing and thorough preparation are essential for best results.

Fertilizing.—The tomato responds to liberal fertilization. It is necessary to produce a large plant quickly to get the best crop.

Phosphorus in ample supply is especially important for both e... ness and large yields. This element is deficient in most soils an... relatively ineffective as a topdressing because it penetrates slo... For that reason phosphorus and potash too should be supplied ... quately in the pre-planting application.

H. J. Heinz

Fig. 97.—Vigorous plants are necessary to produce a heavy tonnage of tomat...

Liberal early fertilization with nitrogen is needed when the ... is cold at planting time but the greatest need is likely to be dur... the fruiting period when the nitrogen reserves of the soil may h... been depleted. In such cases topdressing with nitrogenous fertili... after picking begins is the means of securing substantial increase ... yield. This is especially true of pruned, staked tomatoes which usu... respond profitably to several post-planting applications of nitrog... the first being made about the time the fruits begin to set. If th... walled, flat-sided fruits develop supplemental potash may ... needed.

The characteristics and responses of the variety to be plan... require consideration. In general, the extra early and the ea... tomatoes exhibit only moderate vegetative vigor. They requ... heavy feeding and may receive a relatively large amount of nitro... early in the season. It is generally thought that strongly grow... main crop and late varieties are likely to "go to vine" when ... much nitrogen is supplied before fruiting begins. Some authorit... however, doubt that excess nitrogen stimulates vegetative devel...

ment at the expense of fruitfulness. In any case, the plants profit by large early applications of suitably balanced fertilizers.

On very fertile or heavily manured lands 500 to 1000 pounds of superphosphate to the acre may be the most profitable fertilizer. Under many conditions the formulae 4-16-4 or 4-12-4, at rates of 600 to 1200 pounds an acre, are suitable. However, 4-12-4 or 5-10-5 usually is preferred where leguminous crops or stable manures are not used. Applications of 1500 to 2000 pounds an acre are not unusual for the staked crop.

A high proportion of potash is unnecessary under most conditions but many growers on sandy soils consider a formula approximating 4-8-8 most effective.

Amounts of fertilizer not exceeding 500 pounds to the acre usually are applied in the row and this may be increased with safety when well regulated band placement is secured, especially on soils that are well supplied with organic matter and moisture. A common and very satisfactory practice is to use the potato planter to make up and fertilize rows for tomatoes; many growers prefer to complete that operation at least a week in advance of planting.

Heavy applications can be broadcast and harrowed in before planting, or they may be divided by applying part broadcast and part in the row.

On certain very light soils the usual practice is to put half the fertilizer in the row, preferably in bands, and to withhold the other half until the last cultivation when it is applied as a side-dressing as bands or is cultivated or hilled into the soil near the plants. Then it may be necessary, for best results, to apply additional nitrogen after the fruiting period begins. It is good business to leave a few rows untreated, or to include different treatments, as fertilizer responses vary greatly with difference in varieties, soils, weather, and management.

Lime ordinarily is not applied to the tomato crop but is used in the rotation preceding a more directly benefited crop or green manure. The tomato is relatively indifferent in response to ordinary variations of pH. A reaction below pH 5, however, is likely to be detrimental.

Planting.—Tomato plants should be set in the open ground with as little check in growth as possible. If they are properly grown and handled there should be practically no wilting or checking of growth when the transfer is made. Nothing is gained by setting out too early and exposing the plants to many cool, possibly frosty nights for, under such conditions, they make very little growth and there is risk of serious loss. The plants should be hardened moderately to prepare them for exposure to sun, wind, and cold. Both

earliness and yield are increased by exercising care to transi
plants with little disturbance of the roots (pp. 128, 452, 453
Planting distances are determined by the productiveness
soil, the vigor of the variety to be grown, and the method of c
or system of training to be followed. In thin soils and with
growing early varieties 3x3 feet apart will be satisfactory.
generally 3 or 3½x4 feet are good distances for early vari
4x4 and 4x5 feet are common planting distances for late var
Even more space is often allowed in soils where a rank grov
secured. Spacing of staked tomatoes is discussed later.

The usual hand methods of transplanting are employe
transplanting machines are in common use. In the latter cas
important to use furrow shoes of ample depth so that the roo
extend well down into moist soil.

Ohio Agricultural Experiment Station

FIG. [illegible].—Staked tomato plant pruned to single stem.

Cultivation.—Clean tillage is ess
to high yields. Some hand hoeing u
is required, although this work w
slight if frequent cultivation is pra
as long as the vines permit. Yiel
depressed following the developme
many weeds to a height of only
inches. They apparently utilize th
tilizers very quickly and rob the cr
needed nutrients and moisture.

Staked or trellised tomatoes.—S
stem training of tomatoes has met
universal favor in greenhouse cultur
is an important method in the op
produce fancy tomatoes for the early
kets. The expense of production
creased greatly, but many skilful gro
who are able to market early fruit
premium, find pruning and training
itable. Unquestionably the greatest a
tage is that most of the crop ripens e
In addition the fruits are freer
blemishes, of finer finish, and gen
more attractive than the average of s
mens produced on the ground. In c
quence well grown and carefully p
outdoor trained tomatoes compete suc
fully with the last of the greenhouse

Other important advantages of
ing and training are: less injury
fungus diseases, cleaner fruits tha

e less labor in preparing for market, and greater convenience rvesting. Because the plants may be spaced as close as 15 or nches in rows 3½ to 4 feet apart the early yield and the total ds to the acre can be very large, although the average yield for plant usually is less than with unpruned, unstaked plants set he customary distances. On rich soils, with irrigation, some wers plant 16 inches apart in paired rows 18 to 24 inches apart, 4 feet between pairs of rows. The crowding and shading that lt are useful in reducing sunscald.

Because profit ordinarily depends upon extreme earliness, ecially the yield from the first three to five clusters of fruit, the nts should be the strongest and finest that can be produced, ly large but not spindly. Most growers prefer to have them in d with some bloom at the time of planting. They must be re- ved with utmost care and planted with every feasible advantage. e soil should be in high state of fertility with an abundance of mus, very liberally fertilized—2000 pounds or more to the acre nd additional side-dressing with nitrogen and possibly potash is ly to be required after fruiting begins (pp. 188, 193, 491).

Stakes about 1 or 1½ inches in diameter and 5 or 6 feet high— shorter ones require less labor in setting—are the most common port. Various designs of trellises, usually steel or wood posts h one Number 10 or 12 wire fastened at the top and possibly a ond wire at the bottom, and coarse twine to support each plant, also popular. Some growers place the supports before the toma- s are planted; others prefer to erect them after the plants have n set, although the roots will be disturbed if there is much delay.

Very soon after planting the side buds are snapped out and one, etimes two, strong terminal shoots are retained. Weekly or re frequently pruning is required to remove all side shoots while y are small. As growth progresses the plant is tied to the stake everal places with coarse twine. The twine is first looped or tied und the stake so that it will not slip down and is then tied around plant, allowing ample space for the stem to grow thicker. When lises are used instead of stakes the plants are twisted or twined und the supporting cord. The center shoot or tip may be nipped en the plant reaches the top of the support.

The production of pruned, staked tomatoes is one of the most cialized, intensive, and costly enterprises of vegetable gardening. ancial success is dependent upon careful, thorough-going man- ment and prompt execution of every detail from growing the nts to selling the crop. It should not be attempted on poor soils under other adverse conditions. Application of fungicides is ly to prove profitable wherever foliage diseases are troublesome.

Mulching with straw or other litter helps reduce blossom-end by retaining moisture. Irrigation is almost essential for maxim results and insures the large investment against loss by drou which is probably the greatest risk with the crop. In some locali there is considerable risk of damage by hail which may warrant purchase of hail insurance.

Fig. [illegible].—Careful picking is important in producing a profitable tomato crop.

Harvesting.—The proper degree of ripeness for picking pends on various factors: purpose of the crop as for cannery, sh ment, or local market, distance from market, character of the weath and danger of frosts. In the far South and to some extent in North tomatoes for shipment are picked in the mature-green sta that is as soon as they show a whitish-green color. This results sacrifice of quality, because the best flavor is developed when fruits are permitted to remain on the vine until they are ripe. local markets it is often advisable to pick tomatoes at the pink sta just before they are fully ripe, so that they will reach the consur in firm condition because they lose their firmness very rapidly warm weather. Tomatoes for canning should be picked when fu ripe, a factor of great importance in securing high quality of pa

When there is danger of destructive autumn frosts some grow pick every sound specimen that shows change in color. The fr will continue to ripen in any convenient shelter or in the cel preferably where the temperature is about 50° to 60° F. They ripen rapidly under hotbed sash or in the greenhouse. Tomat

ways should be handled with the greatest care to avoid bruising. nerally the stems are removed at the time of picking.

Yields and costs.—Yields commonly range from 5 to 10 tons an re or about 200 to 400 bushels. Yields of 15 tons are not very usual with skilled growers, and many records exceeding 20 tons ve been reported.

The cost of producing and marketing a well grown acre of canery tomatoes seldom is below $100 and may be higher. An acre of arket tomatoes with greater expense for grading, packaging, and lling, and perhaps for production also, is likely to cost $200 or ore. The cost per ton or bushel generally is inversely proportional yield. The ordinary range of prices paid by canners is about 10.00 to $15.00 a ton.

Marketing.—The utmost care should be exercised in preparaon for market if highest prices are to be realized. Any stems ould be removed and the tomatoes should be cleaned. Cracked, emished, and very small specimens should be discarded. It may ay to grade into two or three sizes and perhaps as many degrees f ripeness.

Packages in great variety are used in handling this crop, but ey should be of a type that will assure minimum bruising. The g box holding about 30 pounds is an ideal shipping package. The 2-quart climax basket, which carries 18 to 20 pounds of tomatoes,

H. J. Heinz Co.

IG. 100.—Inspecting tomatoes at the cannery. Returns to the grower are based on grade and weight.

is used in the Ohio Valley. Open-top, square braided baskets o 12, and 16-quart sizes are popular in the Lake States. In N Jersey, Delaware, and Maryland the ⅝-bushel and 16-quart st baskets are used extensively. In New England flat bushel and h bushel boxes are common.

Tomatoes move through all the usual sales channels and it is individual problem for the grower to choose and develop the ou that will serve him best. Northern markets usually become hea glutted about the middle of August, or earlier in the warmer secti

Insects.—Cutworms and flea-beetles often are destructive to young plants just after they are set in the field. Control meas for these, and also for potato beetles and plant lice which occasi ally may be troublesome, are described in Chapter X (pp. 159, 1

The Tomato worm or Horn worm (*Phlegethontius quinq maculata*) is a large, usually green, voraciously feeding caterpill often they are not too numerous to control by hand picking. C cium arsenate which may be employed to check a general infesta must be applied early because the large worms are difficult to k Recommended formulae are: 2½ pounds of the arsenical an pounds of hydrated lime to 50 gallons of water for spraying pound of the arsenical and 2 pounds of hydrated lime for dusti

The Fruit worm (*Chloridea obsoleta*), which is the same as corn ear-worm and cotton boll-worm, bores into the fruits and i serious pest in the South. The usual recommendations are plowing, planting sweet corn as a trap crop, and spraying w arsenicals. Rotenone insecticides have been reported to be co paratively ineffective.

Diseases.—The tomato is subject to several diseases which m cause serious losses. Control must be accomplished mainly by p ventive means.

Wilt (caused by *Fusarium lycopersici*) is a serious disease tomatoes except in the northerly range of the crop. The cau organism lives in the soil and often is spread by plants from infes beds. It enters the plant through the roots and grows into closes the vascular system which is turned brown—a characteri means of identification. The leaves become yellow and wilt later the plant dies. Control is achieved by rotation, the product of plants free from the disease, and planting resistant varieties which there are several excellent ones as mentioned in this Chap under Varieties.

Septoria blight or Leaf spot (caused by *Septoria lycopers* appears first on the lower leaves as small spots with grayish cent and dark margins. The infection, which is spread most effectiv by splashing rain, develops upward on the foliage. Extensive foliation follows, particularly in warm, wet weather, which o

results in serious reduction in yield and much sunscald injury. General measures of control are: procuring clean seed—that produced in a cool climate or on the first clusters is less likely to be infested; control in the seed bed by weekly application of 2-2-50 or 3-3-50 bordeaux mixture or 20-80 copper-lime dust; rotations of at least 3 years; prompt, clean, deep plowing of diseased tomato refuse, and control of closely related weeds. In the field, timely applications of 4-4-50 bordeaux mixture or copper lime dust at intervals of 10 to 14 days will check Septoria and early blight. The practice is not widely profitable because ripening is delayed slightly, but it is desirable under some conditions. Cuprous oxide or other fungicides (p. 171) may be preferable to bordeaux mixture.

In general the varieties of the Earliana and Bonny Best groups are very susceptible to leaf spot; the Stone (Baltimore) varieties are fairly resistant, and Marglobe and many other varieties of the fusarium wilt resistant class are affected least.

Early blight or Nailhead rust (caused by *Macrosporium solani*) is the same as early blight of potato. Reddish-brown spots with concentric rings appear on the leaves and black-rot spots on the fruit, sometimes causing severe losses in warm rainy weather. Control measures are the same as for Septoria blight.

Late blight (caused by *Phytopthora infestans*), which is common on the potato, sometimes becomes serious on the tomato. It is especially destructive to the green fruits on which the disease appears, often first at the stem end, as a rapidly increasing, water-soaked area. Special control measures ordinarily are not required. If necessary, bordeaux mixture or other materials may be applied to hold the fungus in check, but such applications should begin early to assure effective control.

Bacterial canker (caused by *Aplanobacter michiganense*), **Bacterial spot** (caused by *Bacterium vesicatorium*), and **Speck** (caused by *Bacterium punctilans*) are differentiated as follows by Bryan (Circular No. 282, U.S.D.A.):

"In canker the spot from its first appearance is round and snowy white. It is small, flat, and easily removed by a rub of the thumb. In bacterial spot, the lesions are greenish-white, raised, translucent pimples.

"As they develop, the canker spots form a round slightly raised, tan-colored center, roughened by a single rift or by numerous breaks in the epidermis. The halo remains snowy white and flat. On the other hand, in bacterial spot the whole spot remains raised, with a pale green or greenish-white translucent margin and an irregular, flattened, or sunken brown center in which the epidermis soon becomes torn.

"In late stages bacterial canker still is round and retains the flat, snowy white halo (occasionally it disappears) and raised tan center which remains small 1 to 2 mm (one twenty-fifth to one-twelfth inch) in diameter. Bacterial spot lesions attain a much larger size, often reaching 5 mm (one-fifth inch) and sometimes as much as 8 mm (one-third inch) in diameter. They are round to

irregular. The pale, translucent margin disappears; the center becomes a d sunken crater with raised margin or is slightly raised, flattened, and brown w a darker margin, the epidermis torn and curled back in various directions.

"Only young fruits are susceptible to infection by either disease. The of the fruit at the time infection takes place influences the size of the spot both diseases. The older the fruit when infected the smaller the spot.

"Speck starts as a barely visible brown spot. As it develops it remains tinctly round and flat with unbroken surface, assuming a dark-brown to bl color. There is no translucence or halo at any stage. Spots remains very sm usually 1 mm or less in diameter."

The generally suggested control measures are: (1) Selection seed from healthy plants. (2) Disinfection of seed. (3) Rotati (4) Prompt plowing or destruction of refuse after the crop has be harvested. Spraying in the plant bed and field as described Septoria leaf-spot may be advisable.

Leaf mold (caused by *Cladosporium fulvum*) appears as p spots of mold on the lower surface of the leaves. The disease rare is important in the field but frequently causes serious defoliation the greenhouse. Providing well-lighted and drip-tight houses a ventilating and watering to keep the atmosphere as dry as possil are helpful preventives. Spraying is not satisfactory. Vaporizati of sulphur and strong fumigation of the empty house before plan ing the crop are discussed later (p. 487). Resistant varieties a appearing.

Mosaic (caused by a virus) is a highly infectious disease th appears most prominently as a mottling of the leaves in differe shades of pale green. The leaves usually are deformed and oft develop with only limited surfaces along the main ribs. Plants th become infested while small usually are dwarfed and little fruit borne. The virus of tomato mosaic overwinters in the roots of r lated host plants, and the shoestring form is the one common to th cucurbits (p. 471). The virus is spread from infected to health plants by sucking insects and by the handling or pruning of plant Expectoration by workmen who chew natural leaf tobacco or ciga stubs is a common source of infection.

Control of mosaic in the plant bed is especially importan Plants that are infected early never produce satisfactorily, wherea plants that first attain large size in the field may yield fairly well i spite of later development of the disease. Seed treatment and spray ing are ineffective. Suggested measures are: (1) Control of ho weeds and elimination of tomato refuse around the plant beds an fields. (2) Production of young plants elsewhere than in houses pa tially occupied by bearing plants. (3) Early removal of scattere infected plants. (4) Control of insects. (5) Occasional thoroug washing of the hands with soap, when working among the plants an

nfection of pruning knives with 1 part of formaldehyde in 20 ts of water.

Streak (caused by a combination of viruses), sometimes called ter-blight, is common in greenhouses and sometimes becomes ious in the field. Dark streaks appear on the stems and petioles, tted and dead areas develop in the leaves, the fruit also may be ected, the plants are dwarfed and, in severe cases, die. Streak en develops with great rapidity. Control measures suggested for saic are applicable. Well balanced fertilization may reduce sceptibility.

Blossom-end rot (caused by unfavorable environmental condi- ns) appears first as a small watery spot at the blossom end. The fected area darkens, enlarges, and becomes flattened or sunken. fected fruits ripen prematurely. Blossom-end rot often becomes rious under conditions of moisture deficiency and high rates of anspiration. The difficulty may be aggravated by poor drainage on account of restriction of the root system, close planting, and e presence of excessively heavy foliage from much rain, or over- tilization with nitrogen. Reduction of blossom-end rot may be ected by (1) building up the water-holding capacity of the soil rough liberal additions of organic matter; (2) conserving mois- re by skilful management of the soil both before planting and dur- g cultivation, and, (3) avoiding root pruning when cultivating or eing. Irrigation is helpful and is almost a necessity for the staked op on droughty soils. With steady growth and a uniform supply moisture, blossom-end rot seldom becomes extensive.

All the tomato diseases that may become serious have not been scussed. In general, however, clean seed, plant bed sanitation, ntrol of host plants, plowing or destroying crop refuse, and rota- n will keep most tomato diseases in check.

PEPPER (*Capsicum frutescens*)

History.—The pepper which we use as a vegetable is native to pical America where it was a highly developed and important d plant in early times. Pungent specimens were carried to rope by Columbus on his first voyage. Peppers gained popularity pidly and were soon grown and used almost throughout the world erever the climate permitted their culture. The pepper came into mmon use long before the tomato which now greatly exceeds it in portance. The black and white pepper used as a condiment is oduced from a different group of plants.

Importance.—Formerly, culture of the pepper was restricted stly to the hot varieties, but the introduction of excellent sweet rieties has greatly extended its use. It has become an important

crop that now may be found in city markets throughout the y with the sweet varieties of considerably greater importance. L quantities are used for canning, in preparing tabasco pepper sau and in packing various kinds of pickles.

Climatic requirements.—Although this plant is at home tropical and subtropical countries, it is grown successfully in ne all parts of the United States. It is tender to frost, but does require as high a temperature as the eggplant. The condition southern New Jersey and southward along the Atlantic coast in many parts of the South are especially favorable for vegetable.

Soil.—The pepper thrives best in warm, deep, fairly moist, tile, sandy loam, although it is often grown commercially on mo ately heavy soils. The drainage must be good. A southern expo is preferable in cool regions and will hasten maturity of the crop

Taxonomy.—The garden peppers, according to Bailey, all long to the species *C. frutescens*. The variety *grossum* includes bell peppers of large size, usually mild flavor, and thick walls. is the most important sub-species. Other varieties are: *longum*, "chili" type with tapering, usually pungent fruits several in long; *cerasiforme*, the cherry type with spherical or flattened fr *fasiculatum*, the cluster peppers with erect, slender fruits; *conoi* with very small conical or oblong fruits.

Varieties.—Peppers are divided into two classes, namely, th which produce hot or pungent fruits and those which bear mild sweet fruits also called mangoes.

Pungent-fruited varieties.—*Tobasco* produces an imme number of small, slender, very hot, bright-red fruits. It require long, warm growing season. *Long Red Cayenne* and *Chili* are po lar varieties which are early, long, slender, and pungent. *Hungar Wax* is a first early hot pepper, waxy yellow when young, but cha ing to bright red when ripe.

Mild-fruited varieties.—*Harris Earliest* is extremely early desirable for regions with a very short growing season, but is sm and unsuitable for the general wholesale markets. *Harris Early ant* is a popular early pepper for market and home garden. I good sized, more or less "bull-nosed," and productive.

Ruby King is an old favorite with both market gardeners shippers. Fruits are large and slightly tapering; the flesh is th and mild.

King of the North one of the newer early peppers, is gain favor rapidly and may replace Early Giant.

Worldbeater is similar to Ruby King, shorter, a little la 4-lobed, and preferred by many growers.

California Wonder is a standard late variety with 4-lobed, unky peppers of smooth, handsome appearance. It is unequalled thickness of flesh, and is sweet and mild in flavor. *Waltham eauty*, *Windsor A*, and others have been developed to combine ickness of wall with earlier maturity.

Robson Seed Farms

FIG. 1[illegible]1.—Windsor A, one of the newer peppers bred to combine earliness with thickness of flesh.

Sunnybrook or *Squash* is early, small, tomato-shaped, thick-eshed, mild, and very productive. It is popular on some markets nd with home gardeners.

Oshkosh is the standard, large, yellow variety. It is thick-eshed and of high quality.

Seed.—There is great variation in strains of peppers. Care nust be exercised to secure the best. Some growers produce their wn supplies and maintain superior strains. To prevent the de-elopment of the pungent character in sweet peppers there must be o opportunity for cross-pollination with hot-fruited varieties.

Starting early plants.—A high temperature is required to g minate the seed and to secure rapid growth in the frame or greenhouse. Because early peppers command highest prices, it p in many cases to grow large, strong plants which will produce the earliest possible date. The methods described for grow tomato plants are suitable for peppers. Pepper plants, however, less inclined than many other vegetables to grow spindly and of are grown for the main crop without transplanting. In that metl seed should be sown rather thinly in wide-bottomed drills 4 t inches apart. Some users of this method thin the seedlings to st about 10 to the foot of row and produce excellent plants.

Fertilizing and planting.—In general, the fertilization, time, and the methods of planting described for the tomato are su able for the pepper. Many varieties can be spaced about 18 incl in rows 30 inches apart. The large-growing varieties, however, n require at least 24 inches in the rows and 3 feet or more betw rows on very fertile soils where the growing season is long. Ridg is practiced to some extent to help support the plants when they heavily laden with fruit, but it should be done fairly early to av root injury. The pepper plant is medium in response to lime, usua succeeding well within the range pH 5.5 to 6.5.

Harvesting and marketing.—Peppers may be picked as sc as they attain marketable size, although they wilt quickly if pick too immature. After they reach maturity they will remain in gc condition on the plants for some time. Peppers are gathered snapping or twisting the fruits from the stems. They are sold gre red, or mixed according to demand, and in packages of many sor With favorable conditions, yields of 400 bushels to the acre common, although about half of this is the average in many sectio

Insects.—Control of the general crop insects that attack t pepper is discussed in Chapter X.

The Pepper Maggot (*Zonosemata electa*) may be a destructi pest when red fruits are wanted, especially with the cherry, squa and bull-nose types. The fly deposits eggs in the walls of the frui and the young larva move to and feed on the soft, spongy tissue th supports the seeds. Premature ripening and often dropping of t fruit from the plant follow. When it is full grown the maggot e its way out of the fruit, which usually results in decay in addition the direct injury. Emergence of larva and the development visible injury continue after harvesting, unless the peppers are us very soon. The extent of loss will be reduced by harvesting r peppers frequently and at the earliest acceptable stage.

The most promising means of control are to keep the young pe pers coated with talc dust, a layer of which deprives the fly of t firm footing required to insert her ovipositor into the flesh of t

fruits. The recommendation that follows is by Burdette (N. J. Experiment Station Bulletin 585):

"It is recommended that talc dust at the rate of 25 to 30 pounds per acre be applied when the young peppers are just forming and continued at weekly intervals until about August 10 in southern New Jersey and about August 20 in middle New Jersey. If rain washes the dust off, it must be replaced at once. The dust can best be applied by means of a continuous action hand duster. The nozzles should be set so that the dust is blown on the undersides of the leaves and thoroughly covers the young peppers. A row of peppers should be left untreated in every half acre for a trap row. Beginning about August 1, the larger peppers from this trap row must be picked every week and destroyed either by burying or by crushing so as to destroy the developing maggots."

Diseases.—Seed disinfection and application of bordeaux mixture or copper lime dusts in plant bed and field, as recommended for the tomato crop, are effective against Bacterial leaf-spot.

EGGPLANT (*Solanum Melongena* var. *esculentum*)

History and importance.—The eggplant is thought to have originated in tropical India and in China where it was mentioned by writers at least 1500 years ago. It is a staple vegetable in many oriental countries but remains of minor importance in the United States. The southern and south Atlantic states, New Jersey, and California, however, grow considerable quantities for shipment. In the cooler regions of the North it often is grown in home and market gardens, but seldom in extensive plantations.

Climatic requirements.—The eggplant is more tender than either the tomato or the pepper. Cool nights and short summers are unfavorable to satisfactory yields, but it is produced to advantage in the warmer sections of the Northern states. Especially favorable culture should be provided in the North on account of the sub-tropical nature of the plant.

Soil.—It is generally conceded that warm sandy soils are best adapted to eggplants. Good crops, however, are grown in loam soils that are deep, rich, and well drained. A liberal amount of decaying organic matter is essential to the largest returns. Southern or protected exposures are advantageous in the cooler sections. The eggplant thrives at about the same pH as the pepper plant; however, a reaction no higher than pH 6 is advisable on account of disease relationship (p. 304).

Varieties.—The white, yellow, brown, green, and striped varieties, and elongated or pear-shaped forms, are not popular in the United States. All the commercially important varieties are dark purple colored, large-fruited, and more or less roundshaped.

Black Beauty is the preferred variety among market gardeners and truckers for local market, especially in the North.

Florida High Bush is a vigorous variety, upstanding in grow and well adapted to climatic conditions of the principal shipp districts.

Early Long Purple is an extra early sort for use where warm season is too short for the larger varieties. The fruits oblong, slender, and not popular in the markets. New early variet of recent appearance are *New Hampshire Hybrid*, *Bountiful*, *Blackie*.

Seed.—Well-bred eggplant seed is not difficult to obtain, b seed treatment should be practiced (p. 22). A number of grow prefer to save seed from fruits borne by their best plants. T fruits, which must be blemish-free to avoid blight, should be allow to ripen thoroughly on the plants. Separation and cleaning effected readily by means of fermentation to loosen the pulp a washing as suggested for saving tomato see (p. 21).

Starting plants.—In nearly all parts of the country, glass other protection is required to start the plants. In the North, sowings always are made in greenhouses or hotbeds, while in South, cloth or glass-covered cold frames often are used, especia in starting early plants. The aim should be to grow strong, stock slightly hardened plants ready for the field at the desired time. the North there are few sections where field planting should occ before June 1. To grow plants of the proper size by this date, seeds need not be sown before March 1. Many successful grow prefer to sow later than that.

A temperature of not less than 65 degrees should be provid for germination, and from 65 to 75 should be maintained until plants are set in the open ground. The seedlings require consid ably more heat than tomatoes and somewhat more than peppe If hotbeds are used, it is often necessary to make up two beds, c for the germination of the seeds and the other for the care of plants after they have been pricked from the seed bed. Too mu care cannot be exercised to encourage steady, unchecked grow Stunting the plants at any period will cause hardening of the tiss and will result in decreased yield of smaller fruits.

Most growers make two shifts and some make three. The se lings may first be transplanted 2 inches apart in flats or warm be Later they may be set 3 inches apart and, finally, at distances of 5 6 inches.

A favorite plan in New Jersey is to sow thinly about the mid of February in 1-inch-wide U-shaped drills, 4 to 6 inches ap Thus the seedlings can be grown to about 4 or 5 inches when t are hardened slightly and transplanted 5 or more inches apart e way in beds prepared for blocking. If the plants are grown in dividual containers or blocked, there will be very little check

owth when they are transferred to the field. The fruits will ripen uch earlier and yields will be larger. Moderate hardening before anting outdoors is an advantage, but it must not be overdone.

Soil preparation and fertilizing.—Manure often is applied avily for an early crop, such as lettuce, radishes, or spinach, to be llowed by eggplants. Stable or green manures always should be ovided liberally in the rotation to assure a high state of fertility here eggplants are to be grown.

On account of the late planting date very early plowing is uncessary; 2 or 3 weeks should be allowed, if possible, however, to t the soil into perfect condition and to assure a good supply of oisture.

The fertilizer formulae and the rates and methods of application dicated for intensive production of tomatoes are suitable for eggants. For large yields, strong, early growth and uninterrupted velopment must be assured by an abundance of available nutrits throughout the growing season.

Planting.—Eggplants should never be set in the field until the ound is thoroughly warm. Vigor of the variety, climatic condins, and fertility of the soil are the main factors to consider when ciding upon distances. Four by 5 feet is not too much space when l conditions are advantageous but most growers plant 4x4 or 3x4. wo by 3 feet is sufficient in some cases. Unusual care to avoid uncessary disturbance of the root systems will be rewarded by ineases in the crop.

Cultivation should be done so as to minimize injury to the root stem. It may be fairly deep and close at first and then more and ore shallow as the plants develop. The foliage should be dry fore cultivation or hoeing begins.

Harvesting and marketing.—Eggplants must be picked as soon they attain satisfactory size, but before the surface loses its bright, ossy appearance. Dullness indicates overmaturity and loss of ality. Small pruning shears or sharp knives are used to cut the m close to the fruits.

Eggplants stand shipment well, but should be handled with care prevent bruising. Wrapping in attractive paper bearing the name d the address of the grower is an effective means of advertising d gives protection to the fruits during transportation. Most of crop, however, is marketed without being wrapped and in whater package the market prefers.

Yields vary greatly because of the sensitivity of the eggplant to environment. A yield of a thousand bushels to the acre is not usual with favorable conditions, but the crop may be extremely all under adverse circumstances.

Insects.—The common insects that attack eggplants may controlled by measures recommended for the other Solanac crops. Flea beetles are an especially serious pest of the yo plants. Rotenone dusts are very convenient for their control other materials may be used (pp. 178, 179).

Diseases.—The most serious diseases of eggplants cannot controlled after the plants are infected. The importance of long tations, clean seed, and prevention of contamination of plant b cannot be overemphasized.

Blight (caused by *Phomopsis vexans*) appears as numer brown spots that wither the leaves, and as rotting of the fruits wi become covered with minute black pimples. The disease may come very serious in wet seasons. The organism survives in dise refuse and for three or more years in the soil. Because it may borne on the seed, only blemish-free fruits from healthy pl should be used for seed purposes. In purchasing seed, north sources generally are preferable. Seed treatment should be p ticed (p. 22). Four-year or longer rotations, application of fu cides in the plant bed (p. 287), and the removal and destruct or burying of affected fruits are recommended. Applications copper fungicides in the field may be profitable where blight is of prevalent.

Wilt (caused by *Verticillium alboatrum*) causes yellowing, w ing, and stunting of the plant and may be identified by the discol tion of tissue beneath the bark of the stem. The organism is borne with the seed but lives for long periods in the soil. I favored by an alkaline reaction and inhibited by acidity. A react between pH 5.5 and 6 is suggested. Use of new land where possi and very long rotations are advisable because general establishm of the wilt organism on a farm may make satisfactory productior the eggplant crop impossible. An uncontaminated plant bed is fundamental importance.

XVI

BULB CROPS

THE crops of this group are closely related botanically; they all belong to the genus *Allium* of the family *Liliaceae*. They are hardy and thrive best during cool, moist weather, although warm, dry conditions are desirable during the later period of growth for maturing and curing dry bulbs. Because bulb crops may be planted very closely, respond to high fertility, and require much hand labor they are adapted to the most intensive systems of cropping. The onion is the only one of great commercial importance in the United States.

ONION *(Allium Cepa)*

History.—The onion has been grown since remote antiquity. The oldest records refer to its culture and to its use as an article of food. It probably originated in Middle Asia and regions bordering on the Mediterranean Sea. Ancient inscriptions and records indicate that the onion was among the things desired by the Israelites during the years of deprivation in the wilderness, that large sums were expended to supply onions to the laborers engaged in construction of the Great Pyramid, and that the vegetable was in general use in those early days. Several wild species are native to North America.

Taxonomy.—The onion belongs to the lily family, which also includes asparagus. It is generally a biennial plant which is grown as an annual, although some forms, such as the multipliers, are perennial. The stem remains as a mere disc until the plant starts shooting to seed. The bulbs may be white, yellow, red, or intermediate shades of these colors. The species *(A. Cepa)* includes three botanical varieties. The familiar bulbing onion is planted very extensively to produce dry bulbs and, to a smaller but important extent, for green bunching onions. The multiplier or potato onion, which propagates by branching at the base, and the top or tree onion, which produces bulbils on the tops, are of minor commercial importance. Considerable quantities are planted, however, to produce very early green onions. Garlic, leeks, Welsh or Japanese onions, shallots, and chives belong to other species to be considered later.

Importance.—The onion is important throughout the world and ranks with the valuable vegetable crops in the United States. Its adaptation at one season or another to varying climatic conditions

and its availability the year round give it a place among our most useful vegetables. The commercial areas occupy thousands of acres and it is universally planted in home gardens. The onion crop offers special inducements for the employment of intensive methods.

It is notable that per capita consumption of onions remains fairly constant from year to year and is not very responsive to price changes. In seasons of oversupply it becomes very difficult to market the surplus and losses often occur. In times of domestic shortage continuous demand creates high prices and attracts imports.

Massachusetts Agricultural College

FIG. 102.—Yellow Globe Danvers onions curing in the field. Raked in windrows for topping.

Environmental adaptations and varieties.—While the onion may be grown successfully under a wide range of climatic conditions, it succeeds best in mild seasons without great extremes of heat and cold. When grown in the far South, as in Texas, advantage is taken of fall and winter. A bountiful supply of soil moisture is necessary early in the season, when the plants make very rapid growth. Dry soil and low humidity are favorable for ripening, harvesting, and curing the bulbs.

Fortunately, there are varieties suitable for widely different con-

ditions. They vary considerably in soil preference, hardiness, resistance to insects, diseases, heat or drought, and in response to length of days during the period of growth. It is well known that the early commercial varieties of the South, such as the Bermudas, Early Grano, and Creole, usually produce only small plants and the bulbs ripen too soon when sown in the field in the North.

Investigators have found that the varieties named initiate bulb formation when the days are as short as 10 or 12 hours. Hence it is necessary to start them very early under glass in the North to secure adequate growth before bulbing. In comparison, the minimum photoperiod for normal bulbing of popular late-maturing varieties used in the North, such as Early Yellow Globe, Mountain Danvers, Ohio Yellow Globe, Southport Yellow Globe, and others, ranges from 13.5 to 14.25 hours according to Magruder and Allard. These varieties do not succeed in the South because bulbing is not accomplished before hot weather. They seldom make satisfactory crops below the southern borders of Tennessee and North Carolina or the center of Arkansas.

Varieties of intermediate response, suitable for the earliest crops in the north-central and northeastern states, are Ebenezer, Yellow Strassburg, and Bottleneck. The first named is grown rather extensively from dry sets.

Yellow Riverside Sweet Spanish is a widely adapted variety that is somewhat resistant to heat, thrips, and pink root. It is considered later.

Other factors to be evaluated in the selection of varieties are: market preferences in respect to size, shape and color; time of maturity in relation to competitive conditions—earliness may be desirable or undesirable; keeping qualities and shipping qualities; resistance to insects and diseases; soil adaptation—in general the early varieties require more favorable conditions in order to make a satisfactory crop; the European types which require especially high fertility flourish best on deep, rich soils; the yielding capacity—some varieties produce many more bushels to the acre than others, and purpose for which the onions are to be grown, whether for large bulbs, pickling, or bunching.

American varieties.—These are the hardy, late-maturing, long-keeping varieties that are grown most extensively in the northeastern and central states. The bulbs are dense-textured, firm-fleshed, rather strongly flavored, and have excellent keeping quality. The yellow-skinned varieties predominate in the markets.

Ebenezer.—This variety produces attractive sets of excellent keeping quality and has become important for the production of early mature onions from sets which are planted early in the spring. It is grown also as an early crop from seed. Bulbs are medium to

large, deep-flat, thick-skinned, dark yellow, and of excellent keeping quality.

Extra Early Yellow is useful for the production of the earliest crop from seed, although the bulbs are comparatively flat and of only fair keeping quality and yields average lower than with the late varieties.

Early Yellow Globe is a second early globular variety of general importance. It is about two weeks earlier than Yellow Globe Danvers and of good handling and keeping quality.

Mountain Danvers is a widely popular second early variety. The bulbs, which are slightly flattened, thick-skinned and dark yellow, keep well.

Yellow Globe Danvers is a very popular, medium late variety that has been a leader for many years. The bulbs are medium to large, slightly flattened, globular, slender-necked, and well suited for storage.

Southport Yellow Globe is a standard late variety that produces large, deep-globular bulbs having good storage qualities.

Ohio or Michigan Yellow Globe is a very popular, heavy-yielding late variety similar to Southport Yellow Globe but characterized by bulbs having a somewhat broadened, flattened base.

Australian Brown is planted extensively for the production of sets and to a limited extent for market. The bulbs are deep-flat, thick-skinned, chestnut-brown, strong-flavored, and of exceptional keeping quality.

White Portugal or Silverskin is a widely used variety for the production of sets, pickling sizes, green bunching onions, and mature white bulbs for market. It is second early, semi-flat, and cures well but is a poor keeper.

Southport White Globe is the standard late, white variety and is preferred by some growers for green bunching. Keeping quality is fairly good but inferior to the colored varieties. The flavor is rather mild.

White Barletta is a small, extra early white onion which keeps well and is excellent for pickling.

Bottle onions are much elongated, growing 2 inches in diameter and 5 or 6 inches long with the best culture. They are of high quality and popular in some localities.

Southport Red Globe is the standard late red variety.

Red Wethersfield is earlier, and deep-flat in form. Both are strong in flavor and excellent keepers.

European varieties.—Onions of Spanish and Bermuda types succeed best in the South where large plant growth occurs during the short days of winter before the lengthening photoperiod induces bulbing. They are less hardy than the American varieties, the flesh

is milder and more tender, the bulbs are larger but do not keep well. For satisfactory results in northern latitudes plants that have been started early under glass or secured from the South should be set out as soon as weather permits.

Sweet Spanish, or *Valencia* is the most popular variety of the mild-flavored class among northern growers. It is similar to the former favorite Prizetaker, but is larger, more globular, thicker- and darker-skinned, and keeps better. It is less susceptible to injury by thrips than the American varieties.

The *Prizetaker* or *Denia* type retains its popularity as a shipping onion in many parts of the South.

Yellow Bermuda and *Crystal Wax* are flat, fairly mild, and poor keepers. They are planted extensively in Texas and some other southern areas. *Creole* is a southern adapted variety that is notable for its keeping quality.

Onions propagated vegetatively.—These are of limited commercial importance but are planted to a considerable extent to produce very early green onions. The flavor becomes very strong and the flesh tough in hot weather.

The *Egyptian* or *Perennial Tree Onion* is a hardy sort that produces top sets or bulblets in late summer. These are planted in the fall in the North to produce very early spring bunching onions. The old plants divide at the base forming clumps but never make marketable bulbs.

The *Multiplier* or *Potato* onions are propagated by division of the mother bulbs into segments which in the southern states are set out in the fall to make early green onions. With some overwinter protection they may be grown as bunching onions in the North.

Seed.—Onion seed should be fresh, preferably never more than a year old, and produced from well bred stock. Some seed firms have established reputations for selling high-grade seed of this vegetable, and growers should exercise great care in ascertaining the best source of supply.

While it is less difficult than formerly to procure good seed, a large number of gardeners and onion specialists raise their own. The best time to select the bulbs is at harvest. They should be well cured, of the desired size, shape and color, and slender-necked. Uniformity in all essential characteristics is exceedingly important in choosing bulbs for seed purposes. Seed bulbs should be stored as directed later (pp. 317, 318) and planted as early as possible in the spring, except in localities where fall planting is preferable. The ground should be moderately fertile. Furrows are made 4 or 5 inches deep and 14 to 30 inches apart, depending on the method of cultivation. After the bulbs are placed about 6 inches apart in the bottom of the furrow, they are covered by using a hoe or a small

plow. The long, slender seed stalks should have some support, and this may be provided in two ways: (1) by ridging with soil to a height of 7 or 8 inches, the usual plan, and (2) by driving stakes at the ends of the rows and at frequent intervals and then stretching cheap twine on both sides. The heads turn yellow when mature or ripe. At this stage they should be removed promptly with 6 to 8 inches of the stalk before any seed is lost. As the tops do not ripen at the same time, it is necessary to make several cuttings to reduce loss. A tight vessel or a basket with a cloth lining should be used in collecting the seed. The tops are spread in an airy room with a tight floor or on canvas until they are dry enough to separate with a flail or by other means. Winnowing will remove most of the chaff. The seeds then may be placed, a few pounds at a time, in a vessel of water. The heavy seeds, which sink, are saved, while the light ones and the remaining chaff are poured off. After thorough drying and curing, the seeds may be stored in any dry room.

Soil.—Because the root system of the onion is comparatively limited in range the soil must be fertile and retentive of moisture. The delicate nature of the young seedlings and the great amount of hand labor required in onion culture demand that the soil be friable, not inclined to bake, easily worked, comparatively weed free if possible, and relatively free from stones and rubbish which would interfere with use of drills, wheel hoes, and weeders. Level land is preferred because the seeds, sets, or young, shallow-rooted plants are easily washed out on sloping areas. For the same reason, land that is especially subject to wind erosion is undesirable, unless irrigation is available. Windbreaks may be necessary.

Muck soils provide nearly ideal conditions for the culture of onions and vast areas are devoted to the crop. Much of the production for storage is on these soils where yields are higher and costs are lower than on upland soils which require more manure and fertilizer and greater expenditure for labor. In addition the organic nature of muck soils assures large reserves of moisture, so that drought seldom seriously curtails the crop.

Sandy loams, when properly enriched with organic matter and fertilizers, furnish excellent conditions for onions. They can be worked easily and produce solid, heavy bulbs of superior keeping quality.

Clay soils should be avoided. They become too hard and compact for best results. Clay and alluvial loams, however, when properly handled, yield profitable crops, but the supply of humus must be plentiful to prevent serious baking. Incrustation is especially damaging when it occurs before the plants are up or before they are large enough to permit thorough tillage.

Soil preparation.—The method of preparation will depend mainly upon the character of the soil and the crops previously grown. Fall plowing is often an advantage, especially for heavy sods, new muck lands, and clay loams. A favorite practice before planting any field in onions for the first time is to grow a crop, such as potatoes or corn, which requires thorough cultivation. Coarse stable manures also may be used the year before planting onions. Such treatment will reduce the number of troublesome weeds and increase the supply of humus. Rotation is highly desirable, as it reduces loss from fungus diseases and insect pests and helps maintain proper soil conditions. Other vegetables, such as spinach, celery, beans, and lettuce, often may be used with profit. The selection of the other crops in the rotation must be determined by market, soil, moisture, climate, and labor conditions.

Whatever crops are grown previous to planting onions, the soil preparation must be thorough. If plowing is deferred until spring, this operation should be attended to as soon as the ground is sufficiently dry, and it should be followed by repeated harrowing, managed in such a way as to conserve soil moisture, to germinate and thereafter kill weed seeds, and to prepare a fine, firm, smooth seed bed.

Muck soils, to be used for the first time, require special preparation. They must be cleared, drained, and exposed to winter freezing. Although they are high in nitrogen, sufficient amounts may not be available. On acid mucks lime will help release the needed nutrients and correct acidity. It is generally desirable to grow other crops for a season or more until proper soil conditions have been secured.

Fertilizing.—Stable or green manures must be used freely to maintain favorable physical condition of the soil, a factor of especially great importance in the culture of onions. Because of the very early planting season, green manures must be managed to secure a satisfactory volume of growth during the preceding season, or they may be grown even before the immediately preceding crop so that they will have become well mixed with the soil. Frequent manuring, either with animal manures or soil improving crops, is essential for success with onions on upland soils and is beneficial on mucks. The coarser manures usually are composted to reduce them to the proper physical condition, to prevent excessive top growth at the sacrifice of bulb formation, and to destroy weed seeds. Or, the fresh manures may be applied to other crops in the preceding year or spread in the fall before or after plowing. An excellent plan is to plow first and then apply and disk the manure into the soil. Rotten or composted manure is nearly always used to best advantage in the

spring after plowing thoroughly incorporating it with the soil b
sowing or planting the onion crop.

Applications of commercial fertilizers for onions usually
from 1000 to 1500 pounds to the acre, although rates of 20
3000 pounds are considered profitable by some growers. The
amount ordinarily is broadcast and worked into the soil before
ing. A few growers on upland soils plant in fertilized rows
they prefer to make up a week or more before the plants or se
placed.

On upland soils, fertilizers with an analysis of 4-8-8 or 5-
are used widely for onions, although 5-10-5 is suitable on ma
the well-manured loam types of high fertility. Side or top dr
with nitrogen usually is practiced during the early stages of gr

On muck soils, the recommendations made by Underwoo
Knott (Cornell Extension Bulletin 250) may be followed:

"Onions grown on recently cleared mucks of a woody nature sho
fertilized with 2000 pounds of a 0-12-18 fertilizer. If this analysis can
obtained, 1700 pounds of the 0-10-10 plus 150 pounds of muriate of
may be used. If new muck supported reeds and sedges instead of a
timber, 2000 pounds of a 3-12-15 analysis should be used. On muck th
been under cultivation ten years or longer, 1200 pounds of a 3-12-18 anal
suggested. A side dressing of from 100 to 200 pounds of some readily av
nitrogen carrier, such as nitrate of soda, should be applied on old muck
the onions are from 3 to 5 inches high, especially in a cool, wet seaso
muck that has been in use twenty to thirty years or more, 1500 pounds
4-8-12 analysis will do."

The use of copper, where it is needed to improve colori
discussed on page 101.

Acid soils are unfavorable to the onion crop, although a mod
degree of acidity may not prove harmful on muck or highly or
soils. The lime requirement, however, is high. Upland soils in
ticular should be limed to bring the reaction above pH6, and
some conditions better results will be secured if it is near pH7

Growing onions from seed.—The great bulk of the o
grown in the United States is produced from seed sown in the
ground where the crop matures. This system provides the l
cost of production under conditions favorable for the cultu
onions, and is used almost exclusively in growing the Ame
varieties. Early seeding is regarded of greatest importance.
soon as the ground is prepared fully, the drills should be st
When wheel hoes or garden tractors are to be used it is com
practice to allow 12 to 18 inches between rows. When larger
or horse tools are employed in cultivating, the rows are made
30 inches apart. In ideal ground, close planting and wheel-h
small tractor tillage will secure largest profits. A small, well-tr

can be used to draw the cultivator when the rows are only 12 apart.

fairly heavy soil the seeds should be covered with no more ½-inch of soil. Three-fourths of an inch is sufficient in most while one inch will do no harm in very sandy types. On some soils there is risk of the seed being blown out. Precautions relatively coarse and compact preparation of the soil, conservation of moisture or irrigation, and planting of windbreak rows such

hen the rows are 12 inches apart, 4 to 5 pounds of good seed to re generally will give a satisfactory stand of plants. More seed d be used in heavy soils, because the percentage of germination e lower. Some thinning is practiced by many onion growers, he more skillful ones avoid this tedious operation to a great t. Good growers, by knowing the seed and the soil, differe between 4½ and 5 pounds of seed, for example, to get the d stand. It is customary to allow 8 to 12 plants to the foot of w. Thinning, if required, usually is done at the first handng. Cultivation, other operations, and storage are discussed

rowing dry sets.—Onion sets are very small matured bulbs of ies that grow to large size when favorable conditions are pro. The miniature bulbs are obtained by sowing very thickly to ate crowding, so that a dozen or more plants occupy the same as one when large onions are desired. The crowded plants ete with each other for food, moisture, and room in which to Under such conditions it is impossible for the bulbs to attain size. Onion set production has reached the greatest developnear Chicago, Illinois, and Louisville, Kentucky.

y good onion soil may be used for growing sets but favorable ions are required for profitable commercial production. The ould be moderately fertile, fine, and as free as possible from eeds. The seed should be drilled as soon as the ground can pared in the spring. In the districts mentioned the rows are 14 inches apart. Some highly intensive growers plant closer, is makes cultivation more difficult. From 50 to 90 pounds of enerally are used to the acre. The seed is distributed in a band 1½ to 2 inches wide by means of special, wide-planting with a spreader arranged beneath the seed opening. The fields e cultivated as soon as the plants are up and often enough o the soil in good tilth. The number of cultivations varies wo to six, and of hand weedings from two to four.

th crowded condition the bulbs mature earlier than if they nple space. At Louisville harvesting begins in July and exnto August. The work is begun promptly when the tops are

down and begin to dry. After loosening with a fork or an onion harvester, the plants are pulled by hand, the tops removed, and the soil screened. Then the sets are spread 4 to 6 inches deep in trays and allowed to cure several weeks in open-sided sheds. Diagonal blocks on the corners of each tray or flat assure free circulation of air. When well cured the sets are cleaned again and stored in the trays in frost-proof houses in the manner described later for large bulbs. Shrinkage in bulk from harvest until the middle of February usually is from 25 to 30 per cent. For this reason some growers prefer selling at harvest, when prices sometimes are nearly as good as in the winter. Three hundred bushels to the acre are a large crop. Prices are extremely variable, but the industry is regarded as fairly profitable.

Pickling onions are grown by the same method as sets, except that less seed is used. Twenty-five to 30 pounds to the acre are sufficient. The bulbs range from ¾-inch to 1½ inches in diameter. Uniformity in size is very important.

Growing the crop from sets.—Home gardeners generally depend upon sets to supply green bunching onions and mature bulbs for the family table. This method also has become of substantial commercial importance because the crop matures considerably earlier than from seed sown in the field. Dry sets also are convenient to manage and assure fairly certain and satisfactory results under conditions that are not favorable for good success from seed. On the other hand, the expenditures for sets and planting are important items when large areas are planted. The labor of thinning is eliminated, however, and weeding is reduced. Onion set planters now on the market will do rather satisfactory and economical work in planting sets that have been screened to uniform size. Small sets are best; those above ⅝ or ¾ inch diameters generally produce high percentages of seed stalks and actually cost more because many additional bushels are needed to plant an acre when the sets are too large.

Onion sets should be planted as early in the spring as the ground can be prepared, as there is no danger of loss from freezing at that season. Fall planting in cold climates, however, is unsafe. The rows usually are spaced 1 foot or more apart and the sets 3 to 4 inches apart in the row, although 1 to 2 inches in the row is sufficient for green bunching onions. They should barely be covered in the heavier soils, but the depth may be increased slightly in sandy types. The number of bushels of sets required for an acre will depend upon planting distances and the size of the bulbs. The quantity usually ranges from 10 to 20 bushels. Ebenezer is the most popular variety to produce mature bulbs from sets.

The transplanting or "green set" method is used generally in

growing the Spanish and Bermuda types in the South and is necessary in the North to secure large bulbs of these mild-flavored kinds. Seedlings of planting size can be secured from the South or can be grown by sowing thinly under glass 10 or 12 weeks before outdoor planting time. Moderate temperatures are desirable. Observance of the general principles of good plant growing will control damping-off and produce strong, stocky plants. After the plants reach a height of about 6 inches they are clipped back occasionally to about 4 inches. This practice keeps the tops from becoming tangled and makes the plants easier to handle.

They should not be set in the open ground until after danger of severe frost. Light frosts will do no harm. The plants should be hardened slightly by gradually subjecting them to lower temperatures and by watering more sparingly. Before transplanting, the tops are shortened to about 4 or 5 inches. If properly grown they will be at least one-half the thickness of a pencil when transplanted. Dibbers generally are employed in field planting. Watering is a great advantage after planting, although it is not necessary if the soil is moist.

Fertilization and culture throughout the period of growth should be the best possible as the plants are very responsive to both unfavorable and favorable conditions.

In the South and the Southwest the seed is sown in specially prepared outdoor beds from the middle of September until the middle of October. The seedlings are transplanted in the field from

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FIG. 103.—Topping onions in the field.

November 20 to January 10 or even later. The bulbs often a harvested before fully ripe. After cleaning, drying (in the fiel and topping, the bulbs are graded and sent to market.

Bunching onions, which are used while the tops are green, a of considerable importance.

Because of its hardiness the Egyptian tree onion (top onion) is favorite throughout the North for the earliest bunching onions. T sets should be planted in the fall at least six weeks before freezi weather, and mulched, if possible, with manure after the ground frozen. The green onions of this variety must be marketed ve early to avoid development of extremely strong flavor and ve tough flesh.

In the South the multiplier or potato onions are used for the fi green onions often called "shallots." Large bulbs of this cla planted in the spring, or the unharvested portion of the crop, w divide into many small bulbs suitable for planting in the fall t same season. They generally are planted about six weeks befo freezing weather. The trenches should be 4 or 5 inches deep an the bulbs set 3 to 6 inches apart. The onions will make a good sta in the fall, grow to some extent during the winter in mild localiti and make rapid progress in the spring. When multipliers are plant where the winters are severe, a mulch of some kind, preferab strawy manure, should be applied after the ground is frozen.

In the North, enormous quantities of dry sets are planted to pr duce bunching onions for local markets. It is customary to plant t sets 1 to 2 inches apart, with one foot of space between rows, soon as the ground can be prepared in the spring. Plants of t foreign, mild-flavored varieties are planted to a limited extent produce large green onions of exceptionally mild flavor.

Considerable quantities of bunching onions also are grown fro successive sowings in the open ground, for marketing during the sur mer and fall. This method requires the free use of seed, 20 to pounds an acre. It is an economical method of production th makes profits possible when prices are materially lower than f early bunching onions grown from sets.

Bunching onions sometimes are prepared for market in the fiel but it is better to take them to the packing shed where the de leaves can be removed and the onions properly washed and bunche From 3 to 10 onions are tied in a bunch, the number depending up size and market requirements. Rubber bands are convenient.

Cultivation.—As the onion is a shallow-rooted plant, care mu be taken not to injure the roots by deep tillage. When hard rai incrust the soil before the seeds have germinated, light raking rolling will be advantageous. Hand-wheel hoes and small gard tractors are employed most extensively. Both single and doub

ieel hoes are useful, but more efficient cultivation is accomplished · double than by single-wheel hoes when the plants are small. raight rows and uniform spacing are a great advantage. Narrow ovels or teeth are most effective in heavy soils, while horizontal iives or sweeps are desirable in light soils. The latter attachments ay be used very early without danger of covering the small plants. is necessary to cultivate at least every week or 10 days as long ; growth permits, but deep late cultivation is harmful.

Thinning and weeding.—Thinning usually is performed at the rst weeding, when 8 or 10 plants are allowed to the linear foot of ›w, but, in very good soils and when large bulbs are desired, the lants should stand about 2 inches apart. Special hand weeders are 1 common use. Both weeding and thinning should be avoided as iuch as possible by proper preparation of the soil and adjustment of rills.

Prevention of weed seed development is an important factor in eeping down costs of production on onion lands.

Irrigation.—In the arid West and Southwest the onion crop is rown entirely under irrigation, usually by the furrow system. Vater is applied before planting and afterwards at intervals of a reek or 10 days until the bulbs are nearly ready for shipment, when is withheld to induce ripening. More and more growers in humid egions are employing the overhead system of irrigation. Sprinkling, efore or after planting, prevents the drifting of muck and sandy oils and the accompanying disastrous results in young plantations. rrigation increases yields and insures the crop against loss from rought.

Harvesting and curing.—When bulbs are to be stored they ill keep better if allowed to become fully ripe before pulling. When ie crop is in ideal condition for harvesting, the tops are dead and iriveled and the outer skin of the bulbs is dry. While full ripeess is highly desirable, other factors should be considered: There is anger of second growth, especially if there is much rain; better rices for the early crop may be an inducement to gather part or ll of the crop sooner than if the bulbs are to be stored; when large reas are to be harvested it is necessary to start in ample time in rder to complete the work while weather conditions are favorable id before there is loss from rain. Harvesting usually is begun hen about two-thirds of the tops have ripened at the necks and illen over. Sometimes the remaining tops are broken down about a eek before lifting the crop. August and September are the busy arvesting months in the North, and March and April for the Beruda crop in the South. Timely, prompt handling is important.

It is the nearly universal custom partially to dry or cure the rop in the field. After the bulbs are lifted by hand or with a lifter,

4 to 8 rows are thrown together into windrows, allowed to remai undisturbed for a few days, and then stirred occasionally with wooden rake to facilitate drying. To secure bright attractive bulbs an important factor in getting the best prices, the crop should not b exposed to the weather longer than is absolutely necessary. This i especially important with white varieties which are sometimes cure under cover. After preliminary curing, the crop usually is topped i the field either by machines, which also size and deliver the onion into crates or bags, or by twisting or cutting by hand. Some grower scoop the onions into crates almost immediately after pulling an stack the crates for curing and thereby avoid sunburn.

To complete the curing process the onions usually are kept fo several weeks in crates or slatted trays which are stacked to provid free circulation of air, either in open-sided sheds or with covers in th field. The crop must not be stored permanently until it is throughly cured. Loose skins and dirt should be screened out. Soft and im mature specimens and those with thick necks should be eliminate because they will not keep.

The United States Department of Agriculture (Farmers' Bulle tin 354) gives the following information in regard to storing thi crop:

"The essentials for the successful storage of onions are suitable containers plenty of ventilation, a comparatively low temperature, dryness, and safety fron actual freezing. Any building wherein the above conditions may be securec will answer, but houses of the type shown which are built especially for the purpose, are most satisfactory.

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Fig. 104.—Onion storage in shallow crates or trays.

"The construction of the storage house should be double throughout, with plenty of felt or paper lining. Both top and bottom ventilation should be provided, and the ventilator openings should have doors that may be closed to control the temperature. The floors are constructed of narrow planks with half-inch spaces between the planks for the passage of air. Bottom ventilation is frequently secured by means of drainpipes built into the foundation at the surface of the ground. These pipes are carried some distance toward the center of the house and discharge the cool air at a point where it is most needed.

"The temperature of the storage house should be carried as low as possible without actual freezing. During extremely cold weather the ventilator openings and doors should be kept closed to keep out cold air, and after the onions have become thoroughly chilled the house should be kept closed in order to hold the temperature down and prevent the entrance of moisture during warm or rainy periods. Damp, foggy weather is injurious to onions, especially if it follows a period of cold, and will cause the bulbs to become covered with moisture if the outside air is admitted. A little artificial heat from a stove or radiator may be required during excessively cold weather, but so long as the temperature in the house does not fall below 32° F. there will be no danger of injury. A temperature of 36° to 38° will give good results.

"The best method of storing onions is in standard-size slat crates 20 inches long, 16 inches wide, and 14 inches deep, outside measurements. The material for the sides and bottom is about three-eighths inch thick and 2½ inches wide, four pieces being used to form a side. The corners are reinforced on the inside by means of 3-cornered pieces of oak, to which the slats are nailed. These dimensions provide crates that are interchangeable, the width of five being equal to the length of four. The crates will also nest together when empty, with one inside of two turned together. The full crates are stacked in the storehouse with 1 by 3 inch strips between them to allow for circulation of air.

"Onions are sometimes stored in slat bins holding 100 to 300 bushels each. Bags are also used to some extent, but neither bags nor bins are as satisfactory as the crates, on account of the difficulty in providing the necessary ventilation and change of air through the onions. Bulbs stored in bags or bins must be more thoroughly cured than those stored in crates."

Marketing.—The bulbs usually are separated into three grades: *primes,* which include bulbs 1¼ inches in diameter and larger; *seconds,* which are from ¾-inch to 1¼ inches in diameter, and *picklers,* which pass through a ¾-inch screen.

Onions are marketed in a great variety of crates and bags and in many different sizes and types of baskets.

Yields.—Yields from seed sown in the open ground ordinarily vary from 300 to 1,000 or more bushels an acre, but it is very seldom that more than 1,000 bushels an acre are obtained. Growers sometimes average 600, although 500 bushels are a good yield.

Insects.—The onion maggot *(Hylemia antiqua)* often is very destructive where large acreages of onions are grown year after year. The insect winters in the puparium stage in the soil of onion fields and in refuse and discarded cull onions. Therefore, rotation and the burning or other destruction of all refuse after topping or grading are important. Eggs are deposited in crevices adjoining the base of the plant or in the axils of the leaves. The maggots burrow

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FIG. 105.—Onions stored in slatted bins.

in the bulbs and often ruin a large percentage of the crop. Crosby and Chupp in Cornell Extension Bulletin 278 make the following recommendations:

> "The most practical method of controlling the onion maggot under Long Island conditions is by treating the seed with calomel. Equal weights of onion seed and calomel are used. The seed is first placed in a cheesecloth bag and dipped in a pail of water for a moment to moisten the seed-coat. The damp seed is then placed on a flat, smooth surface and the calomel powder is added. The two are then thoroughly mixed by hand until all the calomel adheres to the seed. The seed should be just moist enough to cause the calomel to adhere to it; if the seed is too wet, a pasty mass will result. It is best to have a deficiency of water at the start and add more as needed. Treated seed should run freely when taken up and pressed in the palm of the hand.
>
> "The treated seed should be sown as soon as possible after mixing. If left too long, part of the calomel will flake off the seed, thus decreasing the effectiveness of the treatment. The loose calomel may also cause the drill to clog. Since the size of the seed is increased by the coating of calomel, the drill openings must be set about two sizes larger for sowing treated seed than for untreated."

Where the seed has not been treated the onion maggot also may be combated by applications of corrosive sublimate solution as described for the cabbage maggot.

Another method is to apply 4-4-50 bordeaux mixture with the addition of 1 gallon of lubricating oil emulsion. Four or five appli-

cations are made at weekly intervals beginning when the plants are less than an inch high. The soil should be saturated in a band at least 2 inches wide, centered on the row.

Onion thrips (*Thrips tabaci*) commonly cause severe injury. The control measures suggested in Chapter X may be helpful when initiated early. Sweet Spanish is fairly resistant and other resistant varieties may be developed. The insects feed at many points where they can not be contacted, as under the sheaths of the leaves, between the young leaves at the center of the plants, and even inside broken or split leaves. The injury is alway. greatest in dry weather. The rasping of the surfaces and sucking of juices by the insects cause the tops to turn light gray, "blast" or "blight," and die. Avoid planting set onions near the location for growing the crop from seed, eliminate host plants in the field and borders, and maintain vigorous growth to decrease the extent of infestation. The following recommendations were issued in 1937 by the New Jersey State College of Agriculture:

"A spray recommended for the control of onion thrip is a mixture of 6 pounds of 60% potassium or sodium oleate soap or 9 pounds of 40% potassium or sodium oleate soap, and 1½ pints of free nicotine (Black Leaf 50) to 100 gallons of water. Because of the peculiar feeding habits of this insect, high pressure must be used in order to make the spray reach the axil of the leaves so as to wet the insect. The application should be made from the top and sides, with a minimum pressure of at least 150 pounds, and each acre should receive approximately 200 gallons of spray. A second and a possible third application may be necessary at weekly intervals, in order to kill the thrips which are not reached or killed at the time of the first spray.

"For the past two years good control of onion thrips has been obtained by the use of napthalene-lime dust. This dust mixture is made up by using 40 pounds of crude chipped napthalene and 60 pounds of good high calcium hydrated lime. The napthalene often gets quite lumpy and may require sifting the material through a screen in order to break up the lumps.

"The amount of material necessary: From 100 to 150 pounds of the dust should be used per acre. In case hoods are used on the dust machine 85 to 100 pounds are sufficient to do a good job.

"Watch your onion fields constantly and keep the plants growing thriftily. If once the plants become set in their growth from any cause the thrips will multiply with unusual rapidity and it will be a hard fight to save the crop. Cleaning up and destruction of crop refuse in the field are very important. After onions, cabbage, and related crops are harvested, clean up the fields and keep them clean, because thrips can breed on any living portion of the plant and on almost any kind of weeds that remain in the field."

A new spray, tested against thrips by the United States Department of Agriculture, is 4 pounds of tartar emetic and 8 pounds of brown sugar dissolved in a little water and diluted to 100 gallons.

Diseases.—Onion smut (caused by *Urocystus cepulae*) is likely to become particularly troublesome in the North when rotation is not practiced. After the land is once in... ted, this fungus is exceedingly difficult to eradicate. Because the plants are susceptible only in the seedling stage, smut may be avoided by growing the crop

from sets or by applying a solution of a quart of formaldehyde gallons of water on the seed in the row. For this purpose the is equipped with a small tank, rubber hose, and stop cock to late the rate of application to about 200 gallons an acre. The tion should be dripped directly on the seed in the furrow before covered. This treatment kills the spores near the seed and al the plants to get started.

Downy-mildew (caused by *Peronospora schleideni*) may come serious late in the season during damp weather with warm and cool nights. It appears first as a purplish mold, and the le soon turn yellow and die. Standard recommendations for co are: practice a 3 or 4-year rotation; burn diseased refuse; locat planting and space the rows so that the tops will dry promptly; secure or produce seeds or sets that are disease-free.

Neck rot (caused by *Botrytis allii* and others) often ca great losses in storage, particularly under unfavorable storage ditions and with white varieties. Control is accomplished by otherwise advisable practices of rotation, sanitation, eliminatio late fertilization to avoid scallions (thick-necked bulbs), clean bags, rapid curing, close topping, careful handling, grading out immediate disposal of scallions, and thorough ventilation throug the storage which should be held as nearly to 32° F. as possible at low humidity.

Smudge (caused by *Colletotrichum circinans*) may cause u shrinkage and sprouting of the northern crop in storage. colored varieties are less susceptible.

Pink root (caused by *Phoma terrestris*) is most troubleson the South and West. Resistant varieties are being developed.

Yellow dwarf is a virus disease to which the Sweet Spa variety is comparatively immune.

LEEK (*Allium Porrum*)

Importance.—This member of the onion family has been c vated since prehistoric times. It produces a sheaf of leaves ra than a bulb. The sheaf is made up of the lower parts of the leaves, is solid and, when well grown and blanched, mild and ten Leeks generally are eaten raw, but they also are cooked and for flavoring. This vegetable is much more popular in France, land, Scotland, and in southern Europe, than in America, where grown mainly for the foreign-born population.

Culture.—Soil and cultural conditions required for onions equally well adapted to leeks. A common plan is to sow ear the spring and thin to the desired stand, although many growers seedlings in either protected or early outdoor plant beds and t

as described for onions. Spacings of 4 to 6 inches in rows 15 or inches apart are suitable.

As the long, white portion is most tender and salable, it is customary to plant the seedlings 4 or 5 inches deep in trenches which gradually filled as the plants grow, or to set them slightly deeper they stood in the seed bed and to hill as the season advances order to blanch the sheaves. They are sold green to some extent. s are stored readily like celery in trenches, cold frames, pits, cool cellars.

GARLIC (*Allium sativum*)

Garlic probably originated in middle Asia and the Mediterranean regions. It has been cultivated from ancient times and is ed for flavoring or seasoning. The demand, however, is limited merican cities. The plant is perennial. Some varieties produce oms but none produces seeds. The bulbs are compound, being with a thin, white, membranous covering about 10 bulblets d cloves.

Culture.—Propagation is effected by planting the cloves early in spring, or in the fall in mild climates. The soil should be fertile well drained. Sandy loams are preferred. The cloves which covered with 1 or 2 inches of soil are planted 4 to 6 inches apart about 1 foot between rows. The plants die down in the early when the bulbs are pulled and cured for a time in the open, as ribed for onions. As soon as the tops are dry they are woven long braids with the bulbs on the outside. Final curing is mplished by hanging the braids in a well ventilated place. The is marketed in braids, or the bulbs are topped and sold in coners.

SHALLOT (*Allium ascalonicum*)

The shallot produces small, compound bulbs called cloves. Ind of being inclosed in a thin membrane as with the garlic, they separate although joined at the base. The flavor is somewhat er than that of the onion. Shallots are used both green and for seasoning and as green onions. The culture is the same as onions grown from sets. The so-called shallots shipped from South during late winter usually are produced from multiplier ns.

WELSH or JAPANESE BUNCHING ONION (*Allium fistulosum*)

This species is perennial, perfectly hardy and grows as clumps lants which are slightly enlarged at the base. Bulbs are not

formed. The Welsh onion may be propagated by division but the most satisfactory method is to sow seed in summer for the production of early spring bunching onions. For this purpose the Welsh onion is of some importance. Seedsmen usually list it as *White Welsh*.

CHIVE (*Allium Schoenoprasum*)

Character and uses.—The chive or cive belongs to the onion family and produces dense tufts of slender, hollow leaves valued for seasoning because of their mild onion-like flavor. The leaves may be cut and used at any time during the summer. Gardeners sometimes lift and pot large clumps.

Culture.—Any good garden soil will grow chives. The plants are perennial and hardy, the roots remaining in the ground for many years. They are propagated by dividing the clumps and should be divided and replanted every three or four years.

XVII

GREENS

FROM ancient times the cooked foliage of many wild and cultivated plants has been considered beneficial in the diet. In recent years authorities in human nutrition have emphasized strongly the health-giving qualities of green vegetables. Spinach in particular has increased in use until it ranks with the principal vegetable crops. Other crops grown as greens are of relatively small importance.

SPINACH (*Spinacea oleracea*)

History and importance.—This plant, which is considered native of southwestern Asia, was probably introduced into Europe during the fifteenth century, and recently has become of general commercial importance. Spinach is planted most extensively for spring and fall crops in the North, for late fall, winter, and early spring shipment from various parts of the South, and for canning in the Pacific coast states and some other areas.

Climatic requirements.—Spinach thrives best during the cooler, more moist seasons of the year and exhibits marked tendency toward premature seeding when grown during warm periods and while the days are long. Suitable varieties, however, can be grown successfully at midsummer in the cooler parts of the North, provided other conditions are favorable. Spinach is hardy, although injury that affects salability often occurs when plants in tender condition are subjected to severe freezes. Fall plantings are wintered with the aid of mulches in parts of many states as far north as Ohio, Pennsylvania, and Massachusetts.

High humidity and rapid growth are conducive to the development of succulent, tender, mild-flavored foliage. Under optimum conditions, only six weeks are required from sowing to harvest, whereas the overwintered crop often is in the ground 7 or 8 months in the North.

Soil.—Spinach can be grown successfully on a great variety of soils as long as they are moist, sweet, well drained, and well supplied with organic matter and nutrients. For the early and overwintered crops, sandy loams are more desirable but the largest crops, as a rule, are produced on the moderately heavy types of soils and on muck.

Lime requirement.—It is doubtful whether any vegetable crop

is more sensitive to acid soil conditions than is spinach. On account of its very high lime requirement, an acidity test always should be made before planting the crop. This is important not only to discover the need for lime but also to determine when lime is not needed.

In case the soil does not need lime its application may involve more than merely unnecessary expense, because excessive liming is a primary cause of the development of chlorotic disorders, a type of yellowing of the foliage.

On that account, and also because the potato or another crop, which is likely to be harmed by much lime, may be included in the rotation, many spinach growers apply only moderate amounts of liming materials, using the finely pulverized forms, and work these thoroughly into the upper 2 or 3 inches of soil. A reaction not higher than pH 6.0 or 6.5 is satisfactory for spinach on most soils. Dolomitic limes may overcome chlorosis on some soils.

Fertilization.—Manures as a rule are applied to the preceding crop, although composted manure may be cut into the soil just previous to planting.

On soils that are amply and regularly supplied with organic matter, suitable commercial fertilizers alone are entirely satisfactory in the culture of spinach. Applications of 1000 to 1500 pounds to the acre are common, although smaller amounts often are used for the fall planting when it follows earlier, heavily fertilized vegetable crops. The formula 5-10-5 is most generally suitable for the preplanting application to spinach, although some growers on sandy types without manure prefer an approximate 1-1-1 ratio such as 7-6-6, and some planters on muck use the formulae suggested for celery and for onions (pp. 256, 312).

Supplemental topdressing, with the standard readily available nitrogenous fertilizers at rates of about 150 or 200 pounds, is a regular practice on porous soils, during periods of cold weather on all soils, and whenever the condition of the plants indicates deficiency of nitrogen.

In this connection it should be noted that sulphate of ammonia generally is considered to have the effect of producing darker-colored foliage, a most desirable market characteristic. About half or more of the nitrogen usually is supplied from this source.

On very porous soils it is common to withhold part of the complete fertilizer for application when the crop is about half grown.

Sometimes the heavy liming necessary for spinach and other acid-sensitive crops in the rotation renders manganese unavailable in sufficient supply and causes chlorosis or yellowing of the foliage. In such cases the trouble has been corrected by the application of 10 pounds to the acre of manganous sulphate sprayed on the plants

in a liberal volume of water. Yellowing from shortage of magnesium may be prevented by using dolomitic limes.

Planting.—The seed bed for spinach should be well prepared to assure prompt, even germination. In fact, a firm condition is most favorable for a strong start of the sowings that are made in late summer and autumn.

The first planting in the spring may be made as early as the ground can be worked. An extra early crop often is grown by planting during the winter on frozen land that had been fitted and marked in the fall. Any time after midwinter when the land is clear of snow, and on a day when a thaw is expected, the covering shoe is removed from the planter and the seed is drilled on the frozen surface in rows between the marks. Or, the seed may be broadcast. In either case the processes of freezing and thawing cover the seed. The labor of cutting broadcast spinach is greater, however.

A succession of plantings can be made during the spring at weekly intervals to provide a longer marketing season. Late plantings, however, which must develop during the long days and usually warm weather of late spring and early summer, are likely to be unsatisfactory in yield and market quality. The last advisable planting dates vary greatly with localities, soils, and the culture given the crop. As a rule, the last large planting is made not later than May first in the milder sections of the North. The crop can be grown throughout the summer in certain cooler regions, however, especially when irrigation is practiced.

Dates for sowing the fall crop also vary. August 10 to September 10 is the principal planting period in many northern states, and sowings are made about 2 weeks earlier or later in accordance with local conditions. If the last plantings do not reach marketable size in unfavorable seasons they are wintered for spring cutting.

Seed for the overwintered crop usually is sown during early September in the North. At Norfolk the planting season extends from September 1 until November 15.

Rows are spaced 10 to 14 inches apart by most growers, although the distance may be 18 to 24 inches on cheap land to permit cultivation with horses or mules.

On low-lying lands and for winter culture, spinach often is planted on low beds, 5 to 9 feet wide, that are made by turning several furrows together. This is standard practice around Norfolk.

The ideal spacing in the row is 3 to 5 inches. Thinning is common practice in the South but Northern growers and those producing for the cannery usually find the cost prohibitive and depend upon adjusting the rate of seeding to produce an approximately correct stand. Very thick stands result in small, spindling plants unsuitable for market and are conducive to early running to seed.

The normal germination of one-year old spinach seed is 80 per cent; much lower percentages are common. Ten to 15, or at the most 20 pounds of seed to the acre are sufficient. As much as 30 pounds may be used in broadcasting.

Cultivation.—On relatively weed-free land, spinach can be grown with little or no cultivation. As a rule, however, one or more close shallow cultivations with wheel hoes or suitable power implements, and a certain amount of hand work are required to keep the crop clean.

Seabrook Farms

Fig. 106.—Spinach for freezing—a scoop replaces the knife in cutting.

Harvesting and packing.—Careful timing of harvest is an important factor in profitable production of spinach. When prices are attractive the crop may be cut as soon as the plants reach acceptable market size. On the other hand, the yield increases very rapidly during the period just before flower stalks become too numerous. However, too long delay results in yellowing of the lower leaves and often prohibitive expense for trimming, and involves the possibility of the crop bolting or losing color more rapidly than it can be sold.

Growers for local markets often find it advantageous to cut spinach early in the morning while the dew remains. The cleanest, neatest product is secured when the crop is cut with a knife, although push hoes and other long-handled tools are used extensively.

Unless the spinach is to be washed, it is trimmed and packed in the field.

Spinach for shipment usually is cut when the foliage is dry. When wet, the turgidity of the plants renders them especially susceptible to bruising, the foliage is likely to be muddy, and the tendency to heat in the package is increased. Placing crushed ice in the center and at the top of the package effectively prevents wilting, heating, and yellowing for a considerable period. This practice is essential when washed spinach is to be transported a considerable distance.

Although washing is conducive to bruising and subsequent decay it may be unavoidable when the crop must be harvested during showery weather and it always is the means of turning out a brighter, cleaner, more attractive pack. An increasing number of shippers, therefore, wash their entire crops, usually in conveyor-type sprinkler washers, and pack in well iced paper-lined packages. If shipment is made by truck instead of refrigerator car, additional ice may be used in and over the load in hot weather. By these means the product reaches the consumer in more attractive condition.

Typical good yields are 400 to 800 bushels to the acre; 1,000 bushels are not uncommon.

Varieties.—The generally important varieties are of the smooth-seeded class. Prickly-seeded spinach, which probably is the parent type, once was planted widely and was considered unusually hardy for overwintering. Very hardy, smooth-seeded varieties of better market type now are available.

For the purposes of the gardener, spinach varieties may be divided into two groups, the savoy-leafed and the smooth-leafed kinds. Within each group there is considerable variation in rapidity of bolting or long-standing (without going to seed) qualities of the several varieties, and in the degree of savoying or smoothness of foliage. It is notable, however, that savoy-leafed varieties often are more finely savoyed and some smooth-leafed varieties more crumpled when relatively low temperatures prevail and the rate of growth is slow, and that the foliage of both types is likely to be smoother than usual when conditions induce extremely rapid growth.

With few exceptions, the savoy-leafed varieties are the most important for shipping and for local markets.

Bloomsdale Savoy is an extremely old variety that has been of great importance. It is very early, vigorous, upright, with crumpled, savoyed leaves having down-curved margins, and runs to seed quickly when grown in the spring. For spring planting it has been replaced to a considerable extent by *Long Standing Bloomsdale,* which has similar characteristics but is a definite improvement over

the parent type, is a few days later and much slower in shooting seed. *Summer Savoy* is similar but especially suitable for sumn and early fall crops.

For the fall and overwinter crop, *Virginia Savoy*, which l been bred for resistance to mosaic, blight, or yellows, has practica displaced the old Bloomsdale Savoy.

Jos. Harris Co., Inc

FIG. [illegible].—Blight-resistant Savoy spinach, in center, compared with susceptible varieties as a fall crop.

Old Dominion is a newer mosaic-resistant variety of the Bloom dale type that is desirable for planting in the fall for early spri harvest, because it does not run to seed so quickly as Virgin Savoy when maturing while the days are long.

Juliana is a leading second early to late variety that is som what similar to *Victoria* and *Long Season*, formerly the favori long-standing varieties for spring planting. The plants are compa growing close to the ground, with dark green, roundish, thick, cru pled leaves which are savoyed less than the Bloomsdale types.

The smooth leafed varieties are grown almost exclusively f canning because of their large size, quick growth, and the ease wi which they can be cleaned. They also are popular on the mark of some cities. *Giant Thick-Leafed* or *Nobel* is an extreme heavy-yielding variety that produces very large, thick, tender leav

...mendous early crop is produced which holds fairly well with... bolting. *King of Denmark* is a long-standing, large-growing ...th-leaved variety that is planted extensively for the latest spring ... The foliage usually is slightly crumpled.

New Zealand spinach which belongs to a different genus is dis...ed separately (p. 332).

Insects.—Spinach aphis (*Myzus persicae*).—This insect often ... serious pest, especially in the fall crop. Even though it may be...e numerous too late to reduce the yield materially, the general ...ence of the insects renders the crop unmarketable. Aphids also ... detrimental as carriers of the yellows and mosaic diseases.

Control with nicotine sprays is relatively difficult on account of ... very low growing habit and savoyed foliage of the plant and the ...ally low temperatures at the time spinach is grown. However, ...ly and thorough dusting with 2- or 3-per cent nicotine dust is ...y effective. The application should be made on a calm, warm ... at a time when the plants are dry. The nozzles must be ad...ed close to the ground or they can be mounted on trailing exten...s of rubber hose. A light canvas or muslin apron should be used ...tain the dust, closely enveloping the plants. About 50 pounds ...ust to the acre will be required.

If the crop has not been appreciably injured but objectionable ...bers of the insects are present, a solution of 1 part of Lethane ... in 1,000 parts of water may be used as a dip to rid spinach of ...ds in preparation for market. Then thorough rinsing will re...e most of the insects.

Leaf miner (*Pegomyia hyoscyami*).—The small, pale maggots ...h mine away the tissue between the upper and lower layers of ...eaves of spinach, beets, and chard sometimes cause serious re...ion in market value, especially of the late spring crop. Because ...ests feed entirely within the surfaces, insecticides are ineffective. ...fic control measures have not been developed, although rota... and strict control of lambs quarter weeds, a favorite host, are ...ful. The earliest spring and latest fall crops usually are not ...ted.

Diseases.—Damping-off (caused by various organisms) is a ...mon cause of thin and irregular stands of spinach. Many of the ...ings may be killed before they appear above ground. Thorough ...ng of the seed with bright red oxide of copper or with zinc ox... (p. 22) is a convenient, very inexpensive, and effective means of ...ating the damping-off diseases of spinach and several other ...

Downy mildew or Leaf mold (caused by *Peronospora effusa*) ...etimes becomes a very destructive disease of spinach. On the ...r surfaces of the leaves it appears as yellowish spots or blotches.

and on the under sides as dense, gray mold. The diseased tissue finally decays or withers away, producing a ragged appearance. The leaves close to the ground are affected first and in severe cases the entire plant is rendered unmarketable. Mildew usually becomes destructive only during rainy periods with cool nights. Applications of fungicides have not proved effective to a practical extent. Rotation, immediate clean plowing of diseased refuse, and proper spacing of the plants are quite effective preventives.

Yellows or Mosaic (caused by a virus) is an extremely destructive disease of the fall or winter crop of the common varieties of spinach over a wide range. The inner leaves of affected plants gradually turn yellow and may die, the outer leaves soon become mottled or yellow and deformed, growth is stunted, and severely affected plants die. The virus has been found to be transmitted from healthy to diseased plants and from one crop to another by aphids. Control is accomplished by planting the resistant varieties —Virginia Savoy and Old Dominion.

Malnutrition disease is caused by unfavorable environmental conditions. The trouble often is associated with high soil acidity and unbalanced fertilization, and is most likely to develop where the supply of organic matter in the soil is low. As a rule the leaves become yellow at the tips, comparatively smooth, thick, and brittle with reddening of the basal portions. On very acid soils the plant remains stunted, becomes very red, and dies when small. Malnutrition usually may be prevented by avoiding extremes of acidity and alkalinity of soil reaction, by moderate, balanced fertilization, and by regular additions of organic matter.

NEW ZEALAND SPINACH (*Tetragonia expansa*)

This crop is of minor importance as midsummer greens, and also is grown to a limited extent as a greenhouse crop. The plants are much branched, often spread 3 or 4 feet across, and thrive best during warm weather. The edible portion is the tender tips of the many shoots. These are snapped or cut to a length of 3 or 4 inches; if cut too long, tough, woody stems will be included. Production continues until cold weather.

Quality is dependent upon liberal fertilization and an abundance of moisture to make rapid, succulent growth. New Zealand spinach grown on poor soils or under droughty conditions usually is unfit for food. Because the common spinach is generally preferred, the market for the New Zealand sort is restricted mainly to the summer season and the demand is quite limited.

The large seeds are very slow to germinate and, for this reason, some growers prefer to start the plants under glass rather than to

control weeds until the plants become established from sowing in the field. Plants for setting in the field also are valuable in securing an earlier crop that will be ready as soon as the last common spinach is gone. Methods described (p. 285) for growing tomato plants without preliminary transplanting are suitable. Spacings of about 2 feet in 3- or 4-foot rows are satisfactory in the field.

New Zealand spinach is quite immune to insects and diseases.

DANDELION (*Taraxacum officinale*)

Importance.—The wild dandelion is frequently used as greens, but the leaves of the best cultivated varieties, are larger, thicker, and more tender. The most common use is for greens, although leaves blanched by tying are valuable for salads. The frilled forms make attractive garnishes. The plants are grown in many private gardens and some commercial growers have found small areas profitable.

Culture.—A deep, rich soil is required to grow large, tender leaves. *Improved Thick Leaf,* the principal variety, is definitely superior to the wild stock. Seed can be sown at any time up to July 1, often following an early crop, although earlier sowings are desirable to produce large, strong roots that will bring about heavy, very early spring growth. Twelve to 15 inches between rows and 8 to 12 inches between plants in the row are the usual spacings. Sometimes the plants are transplanted from early outdoor plant beds. Protection over winter is not required. An early top-dressing with nitrogen will result in an earlier and heavier crop.

Harvesting begins as soon as the plants are of satisfactory size. A strong knife is used to sever the plants just below the crown so that the leaves remain attached in the natural manner. When flowers begin to appear dandelion becomes bitter and of poor quality. Any unharvested sections of the planting may be left for another year, if the flowers are cut regularly with the scythe or mower to prevent seeds spreading as weeds.

In New England, where the demand for dandelion is greatest, the crop often is forced in late winter and very early spring under sash placed over temporary frames made of celery boards.

MUSTARD (*Brassica juncea and B. alba*)

Importance.—Mustard is a member of the cabbage family. It is used as a salad plant and principally for greens. The seeds of Black Mustard *(B. nigra)* are used in the manufacture of the mustard of commerce. Mustard often is grown in home gardens in the South and to a limited extent for commercial purposes.

Culture.—Because the plants go to seed very quickly, rich, moist

soil and cool season of growth are essential. In the North it is customary to sow as soon as possible in the spring for the early crop, in July or August for the fall crop, and in September for the spring crop. Southward it is often started in the fall, for cutting early in the spring. The sowings are made in drills a foot or more apart and seedlings are thinned to 5 or 6 inches in the row. *Fordhook Fancy* or *Ostrich Plume* and *Southern Giant Curled* are popular varieties. *Chinese*, a broad-leafed variety producing a large amount of herbage, is less popular for foliage uses.

KALE OR BORECOLE (*Brassica oleracea acephala*)

History and importance.—Kale is of ancient origin. Several varieties were known to the Romans, and the vegetable probably was used by the Greeks. In America kale has been a potherb of importance since colonial times. It is grown chiefly in the South. Some Northern market gardeners find outlets for limited quantities. Kale is used mainly in the fall, winter, and spring as greens. The plants are very hardy.

Varieties differ greatly in form, size of plants, and character of foliage. The low sorts are hardier than the tall ones, although all varieties winter without difficulty in southern sections, except in severe winters, and sometimes in the milder parts of the North. The most popular variety is *Dwarf Blue Scotch* which is characterized by very finely curled, deep bluish-green leaves of better quality than the *Dwarf Siberian* variety. The latter, however, is considered more hardy. *Dwarf Green Scotch* is similar to Dwarf Blue Scotch but is deep-green in color.

Culture.—Soil adaptation, fertilization, general culture, and control of insects and diseases described for the Cole Crops, Chapter XIII, are suitable for kale. It is important to keep aphids from becoming established.

Planting.—Sowings should be made early enough for the plants to attain full size before cold weather. In the Norfolk region plantings are made from the latter part of July until the middle of September; northward, May is not too soon, though August first sowings will produce a fair crop. Kale usually is sown in 30-inch rows and the plants are thinned to stand 8 to 15 inches apart according to variety. The thinnings may be used as food, to fill vacancies, or to transplant into other fields. A few growers produce fall kale by transplanting from outdoor plant beds in the manner employed for late cabbage.

Harvesting and marketing.—For home use only the more tender inner leaves are taken. Freezing before harvest improves the quality. For market the entire plant is cut, just below the lower

leaves, then it is trimmed and packed dry, as a rule of the United barrels, hampers, or round bushel baskets. Yields of he South and barrels to the acre are common. s find this ods. In es and ns in

COLLARDS (*Brassica oleracea* var. *acephala*)

This is a form of kale which in appearance resembles no. heading cabbage. The edible portion is the cluster of numerous, more tender leaves at the top of the stalk. It is not popular in the North but is grown widely in the South. The plant is said to withstand hot summers better than cabbage and it also is hardy to cold. Culture is the same as for cabbage, except that more space must be allowed—2 or 3 feet in rows 3 or 4 feet apart.

CHARD OR SWISS CHARD (*Beta vulgaris* var. *Cicla*)

Character and uses.—This vegetable is known also as foliage beet. The leaves are thick and broad and the leaf stalks are large and fleshy. It is one of the few potherbs that thrive at midsummer. It is of very little commercial importance, although commonly grown in home gardens. The leaf blades are prepared for the table like spinach, the stalks and midribs are cooked and served as asparagus, or stalks and leaves may be chopped, cooked together, and served as is spinach.

Culture.—Chard is easy to cultivate. The usual plan is to sow outdoors when early beets are planted. The rows should be not less than 18 inches apart. When the young plants are a few inches high, thin to 3 inches and later to 8 or 12 inches in fertile soils. The thinnings may be used as greens.

Fordhook, *Lucullus*, and *Silver Leaf* are distinct varieties. The first is most popular. The plants grow very rapidly and several pickings may be made during the season; the outer leaves are removed and the central bud and leaves are preserved for additional growth, or the entire plant may be cut as is celery. With heavy mulching the plants will winter without injury in some parts of the North. They may be protected readily in cold frames and forced early in the spring.

XVIII

ROOT VEGETABLES

The more popular root crops are grown everywhere by ho
and market gardeners and are planted extensively by truck farm
in favorably situated localities. The general market demand
them is less, however, than for several other classes of vegetab

Soil requirements.—Root crops thrive best in deep soils of
sandy or lighter loam types and most of them produce large yie
on muck. In any case, excellent drainage is required. Favora
soil conditions are absolutely essential to produce shapely roots
sufficiently high grade to compete successfully in the larger ma
kets. These crops, nevertheless, are easily grown and can be pr
duced without difficulty in a great variety of soils, though someti
at a sacrifice of smoothness and brightness. On shallow or v
heavy soils the deeper-rooted kinds are inclined to grow ha
rough, and forked or gnarled.

Climatic adaptations.—All the root crops grow best under co
moist conditions, although the long season kinds—parsnip, ho
radish, and salsify—are planted in the spring to utilize the en
growing season in the North. These three crops are perfectly ha
and may remain in well drained ground over winter in cold clima
when the tops of the roots are protected from alternate freez
and thawing by a covering of snow or of mulching material.

The other root crops, unless they happen to be in very ten
condition, are hardy to frosts and to light freezes. In the So
they are grown in the cooler seasons. The radish is most suscep
ble to injury from heat, and the turnip is nearly as sensitive.
the latitude of the large northern cities the radish is grown m
extensively during the spring and the turnip during the fall s
son. With the aid of irrigation or unusually favorable conditio
a few growers specialize in producing radishes throughout the su
mer.

BEET (*Beta vulgaris*)

History and importance.—The beet is generally believed
have originated in the Mediterranean regions and near Asia. C
tivated forms of the modern type were reported in Germany d
ing the Sixteenth Century. In recent years great improveme
have been made in the breeding of this species which includes
sugar beets and stock beets, or mangels, as well as the table varie

t last are grown in small acreages in nearly all parts of the United tes. Truck farmers grow beets for shipment from the South and canneries in the North and West. Market gardeners find this etable especially adaptable to intensive cropping methods. In ition to the common uses of the roots as cooked vegetables and pickling, the foliage of young beets is valued highly as greens in ne localities.

Soil.—As indicated in the general discussion of soil requirements root crops, favorable soil characteristics are essential when the erprise is to be undertaken on a commercial scale, especially en the product is to be sold on an open market in competition h beets grown under ideal conditions. Fairly deep, moist, well-ined sandy loams are best suited for this crop, especially when rliness is an important factor. When grown in heavy soils beets inclined to be unsymmetrical in form, and also develop unhtly fibrous laterals. Liberal additions of organic matter greatly prove the physical condition of heavy soils, but as fine specimens root crops cannot be expected as in soils better adapted to them. vorable local markets, however, may make the crop remunerave under adverse soil conditions.

Climatic requirements.—The beet thrives best in the cooler rts of the country. When planted southward, advantage is taken the moderate temperatures of early spring. Although the plants e comparatively hardy, severe cold occasionally injures exceponally early plantings and the crop must be harvested and prorted before hard freezing in the fall.

Fertilization.—Beets must grow rapidly to develop the best ality. A high state of fertility and liberal fertilization are necesry for the early market crop.

The lime requirement of the beet is high. In fact, it never should planted without determining the soil reaction and correcting it necessary. Excessive liming is to be avoided because it is conive to the development of chlorosis and scab. Manure also vors scab.

Application of fresh stable manure near the time of planting t crops is undesirable because the expense of weeding will be reased and rank growth of top at the sacrifice of root often foly, or deficiency of nitrogen may develop if the material is very awy. Rotten manure, however, may be applied freely. Some ensive growers use 40 to 50 tons of manure to the acre. A more mon practice is to use one-fourth to one-half as much manure, perhaps green manures, supplementing with commercial fertirs. From 1000 to 1500 pounds generally can be applied at a ch for the early crop, and one-half to two-thirds as much for the crop. Generally suitable formulas are 4-8-8 or 5-10-10 or

sandy soils, or loams, and 3-12-18 on mucks. For the late crop on some heavier soils 5-10-5 or 4-12-4 may be used. The complete fertilizer should be broadcast before planting and worked into the soil.

For the early crop and on very porous soils, top-dressing with nitrogen, usually nitrate of soda, is beneficial. At each application 100 to 200 pounds may be distributed along the rows or broadcast when the leaves are dry. The first and largest application should be made when the plants are a few inches tall, making additional dressings as seem necessary.

Seed.—Most of the beet seed used in the United States is produced in California or imported from Europe. A few gardeners grow their own seed. As the plant is biennial, the roots must be preserved over winter and are planted in the spring as soon as the ground can be prepared. The seed plants grow to a height of about 4 feet and branch profusely; therefore, the roots should be planted about 2x3 feet apart. With careful selection, superior strains may be developed and maintained.

The so-called seed of the beet is really a fruit, usually containing several seeds and surrounded by a corky pericarp. As each so-called seed may produce several plants, care must be exercised to

Associated Seed Growers, Inc.

Fig. 108.—Wonder and selected strains of Crosby Egyptian are the leading beets for bunching.

avoid sowing too thickly. A liberal and constant supply of moisture is necessary to insure germination.

Planting.—Fall plowing is often an advantage for the early varieties which usually are sown in the spring as soon as the ground can be prepared properly. From six to eight weeks are required for the roots to attain marketable size. Under the most favorable conditions early varieties are ready for market in the North by June 1 or 15. Succession plantings of beets may be made until the first of August. Twelve to eighteen inches between rows are standard distances for wheel-hoe or small tractor cultivation. When horses are to be used, the spacing varies from 24 to 30 inches, but 18 inches between rows is sufficient for tillage with a small mule.

By testing the seed for germination and by carefully regulating the drill, approximately correct stands may be obtained without thinning. Light rates of seeding, however, often result in thin, unprofitable stands, especially on the heavier soils and with very early spring planting. For these reasons many growers prefer to sow enough seed to assure a full stand, but not so much that the labor of thinning becomes unnecessarily tedious. Five to 10 pounds of seed to the acre, depending upon distances between rows, or about 10 seeds to the foot of furrow should insure a perfect stand.

Although the rough, angular nature of the seeds is not conducive to uniform distribution, they can be sown with properly regulated general purpose types of vegetable seed drills. One-half inch of covering is ample under most conditions; this, however, may be too little in dry, sandy soils.

When moisture is deficient, germination may be aided by firming the soil which covers the row of seeds. This may be done by the rear wheel of the drill or by other means. With exceptionally loose or dry soil a brick or some other weight may be attached to the drill to provide additional pressure.

Beet seeds do not germinate as promptly as many other garden seeds, and a very few radish seeds sometimes are sown with them to mark the rows so that cultivation may begin early. Slight ridging at the time of sowing (p. 122) is an excellent practice on light, fine soils.

Thinning of beet plants generally is necessary to assure early production and to prevent the formation of many flat-sided specimens. Even in fairly thin stands many misshaped beets may develop in the little clumps of plants that originate from the fruits or compound seeds. The operation can be accomplished most economically and with greatest benefit to the crop when it is started as soon as the plants attain convenient size and is completed before crowding begins. When roots 1½ to 2 inches in diameter are

wanted, thinning to intervals of 2 or 3 inches in the row will provide sufficient space.

Transplanting.—A gain of about two weeks in time of development to marketable size can be obtained by setting out strong seedling plants at the time early cabbage can be planted in the open. The seed is sown thinly under glass five to seven weeks before planting time. Long-continued low temperatures should be avoided as they are conducive to later development of seed stalks instead of marketable roots. It is desirable, however, to harden the plants rather thoroughly during the last week before planting in the field by watering very sparingly, ventilating fully, and holding temperatures moderately low.

The soil must be in perfect condition and the transplanting should be done just before a shower or with the aid of irrigation to prevent checking the plants. Cool, cloudy weather is most advantageous. Skilful management in transplanting determines in large measure the amount of gain in earliness by this method.

Transplanting of thinnings is common practice in the home garden and often is done in the field to fill occasional vacancies.

A principal objection to transplanting beets for market is that the tap roots are bent or broken causing the development of crooked or numerous roots which spoil the appearance of the product.

Cultivation.—Frequent shallow tillage combines the requisites of controlling weeds without injury to the root system.

Harvesting and marketing.—Harvesting of early beets usually begins as soon as they attain a diameter of about 1¼ inches and is completed before they exceed 2 inches. Larger beets are not wanted on most markets. Because delay of a few days often makes a great difference in prices, and the roots quickly grow too large, it usually pays to dispose of the crop as rapidly as possible.

Bunched beets are tied in bunches of 3 to 6 according to size and market custom. Bunching is done most economically in the field when the beets are pulled. A very satisfactory grade can be maintained when the foreman requires the workers to remove all dead or unsightly leaves and tie uniform sizes together. Effectual washing is necessary to secure clean, bright appearance.

To sell well, bunched beets must have fresh attractive tops, and these are exceedingly perishable. Beets wilt quickly upon exposure to the air and the foliage may heat, blacken, and decay overnight when the crop is improperly packed in closed containers, or is piled deeply.

Prompt removal from the field to the packing house to prevent wilting, careful handling to avoid bruising, and chilling with cold water to remove the field heat are necessary to preserve attractive appearance and table quality.

For many markets, 6 or 12 bunches are bundled together and sold without packaging. Closed containers are more costly but protect the product better, and must be used for shipment. Paper linings and the addition of crushed ice to the pack often return an excellent profit and are almost a necessity for long distance shipment. Refrigeration in transit is essential for bunched beets shipped to distant points.

The demand for cut-off beets during the winter season formerly was large. The nearly continual presence in the markets of fresh bunched beets from the South, however, has reduced this outlet until very few growers find it profitable to grow late beets for storage. In topping beets the petioles are severed about ¾ to 1 inch above the crown.

The late crop may be stored in various ways. Burying is a popular method. Cellars and pits often are used (p. 207). Unless the humidity is high, or the roots are protected by a covering of moist sand or soil, serious losses may occur by shriveling.

Yields and returns are variable. Yields of 2000 dozen bunches or 300 to 400 bushels to the acre are considered good for garden beets, although larger crops are harvested.

Color.—The development of deep red interior color, with the minimum of light or white zoning, is a matter of importance, especially in producing beets for the cannery. The first consideration is to secure seed of a variety or strain of good color characteristics. Conditions that tend to improve color are: late planting, relatively low temperatures, moderate instead of rapid growth, and storage. Upland soils are preferred in some cases to mucks for the production of well colored beets.

Varieties.—In the Sixth Report of the New York Agricultural Experiment Station, Goff grouped the varieties of beets under four general classes, namely, root oblate or top-shaded, root oval, root half-long, and root long conical. Only the first is of material commercial importance. Each of these classes is divided into subclasses based on color—red or yellow. The four types of beets which have been developed from *Beta vulgaris* are common garden beet, sugar beet, mangel or mangel-wurzel, and swiss chard which is used for greens.

In considering varieties of table beets growers should realize that different seedsmen may offer strains or selections which differ materially in form, color, earliness, and vigor. For example, Crosby of one seedsman may be practically identical with Wonder of another; one stock of Detroit Dark Red may be comparatively refined in size, form, and vigor; whereas, another may be larger, later, and rank growing. It will require careful consideration of the descrip-

tions of reliable seedsmen and actual trial by planting small
to secure the best and most suitable stocks.

Crosby or *Crosby's Egyptian* is a leading variety for early bu
ing and is preferred by many planters for the midseason
later crops. It is very early. The plants are medium-sized.
roots are flattened, globe-shaped with a very slender tap root,
colored in the best strains, and of fine quality. *Wonder* is sl
and, as a rule, fuller at the bottom and of more refined appea
than the less well-bred strains of Crosby Egyptian. These
are planted almost exclusively for the early markets and, as st
also are popular for later sowings.

Early Flat Egyptian or *Extra Early Egyptian* is used to a li
extent in forcing and for the earliest markets. The tops are
and erect. The roots are flat with considerable white zoning o
flesh. This type is not materially earlier in outdoor culture
the best stocks of *Crosby Egyptian* or *Early Wonder* and, as a
is inferior in form and color.

Detroit Dark Red is the most popular main crop variety.
planted extensively for market, cannery, and home use. The p
are medium to large. The roots of well bred strains are glo
dark red, without white zoning, and of good quality. Detroit
Red is about 10 days later than the early varieties, and req
approximately 60 days from planting to marketable stage.

Canner is a small-topped midseason beet of exceptionally
color, shape, and uniformity. It is desirable for cannery use
the home garden, but the tops may be too low, small, and b
for a bunch beet unless conditions are very favorable.

Long Smooth Blood or *Long Dark Blood*, which produces
about 12 inches long, nearly half above ground, is a popula
variety of excellent color and keeping quality. It is two or
weeks later than *Detroit Dark Red* and must be sown corresp
ingly earlier for a fall crop.

Long Season, *Century*, *Winter Keeper*, or *Dark Green Lea*
the same or similar, very late, excellent quality, green-leafed
that are considered superior to all others by some gardeners.
roots are dark, purplish red but are hairy with fine roots and
the uniformity and smoothness required in a beet for general
keting.

Insects.—The Leaf miner (*Pegomyia hyoscyami*) was disc
under spinach (p. 331).

Flea beetles, web worms or other chewing insects that s
times attack beets should be combated with rotenone or pyret
preparations instead of arsenicals to avoid danger of pois
residues remaining on the foliage. Although about 200 spec
insects feed upon the beet, most of them are unimportant.

s are the most destructive pests and often must be guarded t in the earlier plantings (p. 178).

iseases.—**Leaf spot** (caused by *Cercospora beticola*) is a pread disease that seldom does much damage to the garden of beets. Sanitation and rotation are recommended. Spraying Bordeaux mixture can be practiced with some benefit where sary.

Scab (caused by *Oospora scabies*) may become a serious dis- of garden beets. The organism is the same as that which s scab of potatoes. There is no remedy after the crop becomes ed. Control is accomplished by rotation so that the seed may anted in soil that is free from the fungus. Liming should be ted to the minimum where scab is known to be present (p. 417).

CARROT (*Daucus Carota var. sativa*)

History and importance.—The cultivated carrot probably orig- d in middle and western Asia. Although it was cultivated by ncients, its common use as a vegetable and the present form ably date from about the Middle Ages. Within recent years opularity has increased greatly. It is widely grown for local and extensive plantings for shipment are found in favorable ties.

Climatic requirements.—The carrot adapts itself to a wide e of climatic conditions. Although it is essentially a cool sea- rop and succeeds best with moderate temperatures it is quite ant of heat. While it is hardy, both tops and roots being able thstand some freezing, it will not survive the cold of northern rs. It was found at the New York (Cornell) Agricultural riment Station that a temperature range of 60° to 70° F. is ucive to the development of greatest growth, best color, and al shape of root with the Chantenay variety.

Soil.—The soils described as well adapted for beets are suitable arrots, although the carrot is more exacting, especially to pro- long smooth roots. Because the seeds are rather slow to ger- e and the young carrot plants are very delicate, they should anted in soils that have little tendency to bake or crust and airly free from weed seeds. Heavy manuring and clean crop- during the previous year provide best conditions. Although moothest and best shaped roots are grown in fairly sandy soils, s are grown successfully on all deep loam soils except clay. tionally large yields are secured on muck. Thorough, deep, h preparation of the seed bed is important.

Fertilization.—The carrot, like other root crops, requires a amount of potash, and may be even more responsive to this

nutrient than are some of the others. On upland soils 1000 to pounds to the acre of the analysis 4-8-8 or 5-10-10 are gen satisfactory, although 5-10-5 may be used on well manured or ier types of soil. For the fertilization of carrots on muck, re the recommendations for the fertilization of onions (p. 511) b rates of application generally should be increased slightly.

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FIG. 100.—Imperator is typical of the long bunching carrots that are popular in the markets.

Fresh stable manure should never be applied immediately b planting carrots. Rotten manures always can be used to adva and may be applied in liberal amounts.

Liming specifically for the carrot crop probably will not be n sary on soils that are in good state of cultivation. The car tolerant of a fairly wide range of reaction, usually pH 5.5 to and the lime requirement is considered medium to low.

Seed.—Carrot seed of excellent breeding can be obtained cheaply than the average grower can produce it. Seed produ at home, however, may be accomplished by preserving well-se roots over winter and planting them in the open as early i spring as possible. Spacing 2 by 4 feet apart is recommended

Planting.—For the production of an early crop of root

must be sown as soon as the ground can be prepared in the . A succession of young roots with bright foliage is secured nting the same variety at intervals of two or three weeks. 8 to 10 weeks are required for the earliest varieties to mature bout four months for the late. The latest varieties should not nted in most sections of the North after the middle of June. rious planting distances are used by different growers. e inches between rows are sufficient for the small early vari- and 15 or 18 inches are ample for any variety. Some growers r to plant 24 to 30 inches apart and to cultivate with a horse. he amount of seed that will be required depends on viability, ype, spacing between rows, and the desired thickness of stand. narily 2 to 4 pounds of seed are required to plant an acre. arrot seeds germinate slowly and it is an advantage to sow th radish or turnip seeds with them to mark the rows. Tillage tions then may begin sooner. The seed should not be covered deeply than necessary to furnish the proper supply of mois- ordinarily ½ inch of soil is sufficient.

n some localities it is standard practice when planting carrots row a slight ridge of soil over the seed by means of very small at the rear of the drill. The seed is placed about one-half below normal ground level. When frequent examination shows the seeds have begun to sprout the ridge is knocked down with nt drag, somewhat similar to a hotbed sash without glass. Thus crust is destroyed and the seedlings emerge without difficulty e narrow, freshly worked, weed-free strip. On heavier soils idge may be removed with the back of a rake (p. 112).

o a limited extent, especially for soils that bake, carrot seed is ted before planting (p. 211). It must be sown just as soon hite tips appear.

hinning to distances of 1 to 3 inches in the row is practiced al- universally, although a certain amount of crowding is not ob- nable on rich, loose, upland soils or on muck. Too much ding results in spindly tops and blackening of the lower leaves, is very undesirable when the crop is to be bunched.

ultivation should begin as soon as the rows can be seen and be repeated at very frequent intervals during the early stages owth. Otherwise, weeds are likely to smother the carrot seed- which grow very slowly at first. More or less hand weeding essary to destroy weeds in the row.

arvesting and marketing.—Marketing of early carrots usu- egins as soon as the roots attain acceptable size. Ordinarily roots are tied in a bunch and, for local markets, one-half or a dozen bunches are tied in a bundle. Grading to fairly

uniform size in the bunches and thorough washing are necessary to secure best prices.

To make washing easier and to secure the brightest, freshe appearance it is important to prevent the surface of the roots fro drying between the time of pulling and washing. After they ar dry it is practically impossible to get the roots perfectly clean. O dry days some growers carry a barrel of water and a sprinkling ca on the harvesting wagon or truck and then sprinkle the tiers of roo as rapidly as they are harvested and loaded. As loading progress a canvas cover is used to prevent drying.

The general suggestions that have been made for handling bee or spinach in closed containers are almost as important for bunche carrots which are to be shipped.

Cut-off carrots are easily stored as explained in Chapter X and they keep better if not too mature. However, the presence of fresh, bunched carrots on the markets throughout the winter h reduced sharply the demand for cut-off roots.

In compact soils harvesting can be facilitated by loosening th roots with a celery lifter or potato digger, or by turning a furro away from the row, leaving the roots close to the edge of the lan side. Sometimes a subsoil plow or a "rooter" is used.

Yields of 10,000 to 15,000 bunches or 300 to 600 bushels of cut-off roots to the acre are common, with heavier yields on muck.

Varieties.—The range of carrot varieties includes short, hal long, and long forms with either pointed or blunt lower ends; white yellow, orange or red, and purple colors, and considerable variation in earliness. Very early plantings of the earliest varieties sometime bolt, or send up flower stalks the first year, when allowed to gro over a long season but the standard varieties are biennial. Th orange-colored varieties are the only ones grown for table use.

Early Scarlet Horn, very early, and *Oxheart*, early, are we known, very short carrots that are planted to a limited extent, par ticularly on heavy soils.

Chantenay was the most popular early bunching carrot for great many years. It is medium in length, square shouldered, ta pering, and of good quality. *Red Core Chantenay* was develope for solid orange interior color, instead of the lemon yellow core *Rubicon* is similar. Special longer strains of Chantenay also ar available. Chantenay is one of the best all-purpose carrots an may be preferable on heavy soils to the longer bunching varietie commonly grown for shipping.

Imperator, Perfection, and *Bunching* recently have become ver popular as bunching carrots. *Streamliner* is one of the newest o this group. They are only slightly later than Chantenay, longe and more slender, and of the form most in demand in the market

Tendersweet is gaining some prominence as a long, tapering bunching carrot of deep reddish-orange color.

Danvers Half Long is an old standard main crop variety with medium to long, square-shouldered, tapering, and somewhat blunt-pointed roots. *Hutchinson* and *Bagley* are very heavy-yielding,

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Fig. 116 — Red Cored Chantenay is one of the best carrots for soils that are unsuited to the long varieties.

longer selections of Danvers type but with round shoulders which tend to grow above ground and become green, especially with Hutchinson.

Nantes, Touchon, or *Coreless* are early, cylindrical, round-shouldered, stump-rooted, and of excellent interior color. They possess the highest table quality of all carrots. This type is not a heavy cropper except on muck or other ideal soils and the small

amount of delicate foliage renders it unsuitable for the general trad in bunched carrots.

Insects.—Carrots may be injured by the feeding of larvae o the carrot rust fly or the carrot weevil, the carrot beetle, wire worms and other pests that burrow into the roots. Under most condition control is effected by fall plowing, destruction of infested refuse, an rotation.

One of the several treatments suggested for controlling th maggot of the rust fly is to apply a mixture of 3 ounces of calome in 10 gallons of water in narrow strips along the rows of youn plants. Two or three successive, weekly applications are recom mended. The same pest attacks celery, parsley, and parsnips.

Diseases.—Foliage diseases, **Leaf spot** (caused by *Cercospora apii carotae*) and **Leaf blight** (caused by *Macrosporium carotae*) when known to be troublesome, which usually is with the late crops, can be controlled by weekly application of 4-4-50 bordeaux mixture or 20-80 copper-lime dust beginning when the plants are about 3 inches tall.

Soft-rot is combated by long rotations, careful handling to avoid bruising of roots for storage, and disinfection of storage structures (pp. 426, 465).

PARSNIP (*Pastinaca sativa*)

The parsnip is of Mediterranean origin and has been used as a vegetable for 2,000 years or more, but it is not generally importan or widely popular. It is a biennial belonging to the family *Umbelliferae* and is closely related to parsley, carrot, and celery. It is grown as an annual and requires a full season to produce a good crop.

Culture.—Deep, fertile, sandy loams grow the finest roots. Clay soils have a tendency to produce crooked and branching roots which are not wanted by the market. Favorable conditions are necessary to produce straight, smooth, clear, white roots that will sell to advantage.

The lime requirement of parsnips is high. Fertilizer practices recommended for beets are suitable. Thorough preparation of the soil is advisable.

Parsnip seed soon loses vitality. Fresh seed should be used as seed more than a year old seldom produces a good stand of plants. The seed, which germinates very slowly, should be sown early in the spring, although May plantings are preferred to avoid the production of oversized roots in some localities with a long season. A few radish seeds sometimes are sown with the parsnips. They germinate quickly, and the young plants mark the rows, so that cultiva

tion may be started before the parsnips are up. This method is especially desirable in soils that have a tendency to bake. One-half inch of soil is sufficient covering. As the seedlings are very small and delicate at first, it is customary to use plenty of new seed and then thin the plants to stand 3 to 5 inches apart. There should be 15 to 18 inches between rows for wheel-hoe cultivation, and 2 feet or more when horse-drawn implements are to be used.

The roots may be used any time after they have reached maturity. Most gardeners who grow parsnips in large quantities dig part of the crop in the fall, burying the roots in pits or storing them in caves or cellars. To prevent drying and shriveling in storage, they should be covered with moist sand or soil. As the roots are hardy in all parts of the North, part of the crop usually is left in the ground where it was grown until the weather is suitable for digging in the following spring. Freezing or storage near the freezing point improves sweetness. Parsnips are easily grown, and all markets usually are well supplied. Yields of 500 bushels to the acre are common.

In some markets there is a demand in late summer and fall for young parsnips bunched in the same manner as carrots.

Hollow Crown is the most important variety. *Model* and *Ideal* also are popular. They are less hollow crowned and fuller sided.

TURNIP *(Brassica Rapa)*

History and importance.—This cruciferous vegetable originated in Asia and the Mediterranean regions and was cultivated by the ancients. When planted in the spring most varieties go to seed soon after usuable roots are formed, but when grown in the fall the roots must be stored during the winter and replanted the following spring for the production of seed. The turnip is one of the moderately important root crops, and is grown extensively as a fall crop and to some extent for early summer use.

Soil.—Like other root crops, the finest specimens are grown in sandy soils although the crop is produced in a wide range of soil types. To secure large yields and high quality the soil must be fertile and there must be a constant supply of moisture until the roots have attained marketable size.

Climate.—The turnip thrives best in a cool, moist climate. As only 6 to 9 weeks are required from seed sowing to maturity, it may be grown successfully in the most northern agricultural regions. In fact, much of the commercial production is in northernly localities where insects are less troublesome. Turnips also succeed well as late fall or winter crops in the South. The foliage is hardy and the

roots may be unprotected in the open ground until there is dang of hard freezing.

Sowing.—For the early crop, sow as soon as the ground can prepared; for the late crop in the North, sow the latter part of Ju or in August, depending on locality, or approximately 8 weeks befo hard freezes occur. The rows may be 12 to 18 inches apart intensive culture or about 30 inches if a large cultivator is to employed. The tendency is to sow the seed too thickly and th necessitates a large amount of labor in thinning. If one good seed dropped to every inch of furrow the stand should be satisfactor even then thinning may be required. For the early crop the plan should be about 2½ to 3 inches apart but for the larger late variet 4 or 5 inches between plants in the row will not be too much spa The seeds should be planted about ½ inch deep. For the late cr the seed often is broadcast in well-prepared soil, and then raked very lightly. This is a favorite plan on general farms where t inferior roots are used for stock feeding. When roots of unifor size and high quality are desired for market, it is better to sow drills, so that cultivating, weeding, and thinning can be proper attended to. One or two pounds of seed to the acre in drills or tw to three pounds broadcast are the usual rates of seeding.

Fertilizing.—Turnips are thought by growers to require som what less potash than other root crops. The analyses suggest for beets are generally satisfactory. Rates of application ran from 1000 pounds to the acre for the early crop to one-half or tw thirds as much for the fall crop. When they succeed heavily fe tilized or manured early crops, little or no fertilizer may be need for fall turnips. The lime requirement is relatively low in compa son with that of beets and parsnips.

Harvesting, marketing and storing.—Turnips are handled the same general manner as are other root crops. The spring cro usually is sold bunched and the fall crop with the tops cut off flu with the tops of the roots. Thorough washing and grading are ne essary to produce a readily salable pack. Turnips may be stored b the usual pit and cellar methods. Yields are similar to those beets and carrots.

Varieties.—*Early White Milan* and *Early Purple Top Milan* a popular early, flat varieties for bunching. *Purple Top Strap Leave* is an important second early flat turnip.

Purple Top White Globe is by far the leading variety for th main crop. It produces large, purple or red topped, globe-shap roots with white flesh of very high quality.

White Egg and *Golden Ball*, the latter with yellow flesh, a planted for both second early and late crops.

Seven-top and *Shogoin* are popular in the South as foliage tur- which are planted for greens.

Insects and Diseases.—Aphids, flea beetles, and cabbage root ggots often are very destructive to turnips. Control of these in- ts is discussed in Chapter X and under cabbage insects in Chap- XIII. Maintenance of very vigorous growth is notably helpful avoiding serious trouble with aphids.

Club-root and black rot seldom become troublesome on turnips ere cabbage or other cruciferous crops do not appear in the ation more frequently than once in four years. Details of control found under diseases of cabbage.

RUTABAGA (*Brassica Napobrassica*)

The rutabaga is known also as Swedish Turnip or Swede. The ant is differentiated from the turnip by smooth, non-hairy leaves, nore or less elongated crown or neck, and larger edible roots. The sh is considered finer grained and richer than the turnip.

Culture.—The rutabaga requires practically the same culture as turnips and is grown on a large scale only where the summer is ol, mainly in Canada. It is subject to the insects and diseases mmon to the *Cruciferae*.

There is limited demand for early rutabagas which may be own from seed sown as early as possible where the crop is to ma- re. Plants also may be used for the early crop but rougher roots e produced.

Both rutabagas and turnips are likely to become woody and tter very quickly when produced in warm weather, and the princi- l demand for both is during the fall and winter. The usual custom to plant rutabaga seed from the middle of June until about July 6 rows 18 or more inches apart and then thin to about 6 or 8 inches.

Purple-Top Yellow or *Long Island Improved* is the most im- rtant variety. It is yellow fleshed. White fleshed varieties such *Macomber* are of some importance. Care should be exercised to cure a good strain.

Harvesting should be completed before severe freezing weather. utabagas store well with moist conditions and temperatures close the freezing point that generally are suitable for root crops. In eparing the crop for market it is often waxed to improve appear- ce and keeping quality (p. 190).

RADISH (*Raphanus sativus*)

History.—The radish, which has been cultivated since earliest storic times, probably is indigenous to China and Middle Asia. It

was popular with the ancient Egyptians and Greeks and is use
day by the peoples of many countries.

Importance.—The radish is particularly important in this
try as a spring and early summer crop but it is grown somev
at all seasons. In certain especially favorable areas the rad
grown rather extensively to supply city markets. Southern tr
ship to the North and the crop is generally grown by market

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FIG. 111.—Early Scarlet Globe, the leading commercial radish. Strains have been developed for different outdoor conditions and for forcing under glass.

deners. Radishes are a greenhouse crop of some importance.
market for radishes is easily oversupplied.

Cultural requirements.—This is a hardy, cool-weather
but it may be grown under a wide range of climatic conditio
using suitable varieties and providing very fertile soil with
amounts of moisture. Sandy loams and muck are preferred
heavy soils the roots are likely to be rough or ill-shaped, with a
number of small, fibrous laterals.

Decayed manure may be used in large amounts, but fresh
ure should never be employed immediately before planting
5-10-5 or 4-8-8 fertilizer, applied at the rate of 500 to 1000 p
to the acre, should produce excellent results if other conditio

-able. On soils that are manured very heavily 4-12-4 or even -rphosphate alone may be more desirable to avoid excessive -th of foliage. The lime requirement is low to medium.

-he very quick growth and small foliage of the most popular -ties of radish make this one of the most adaptable intercrops.

Seed.—The best radish seed is uniformly large and plump and be of high vitality. Earlier crops and crops of more uniform and maturity always are secured when the smaller and lighter have been eliminated by severe screening or windmilling. This very important advantage in commercial plantings where the -e crop is usually harvested at one pulling. By sowing at appro- -te intervals, a constant succession may be had through the sea- Specialists in producing the quickly-maturing varieties some- sow twice a week, at least weekly, to have continuous supplies. -erent strains or varieties may or may not be required as the -on advances.

Precise regulation of the seed drill is a matter of extreme im- -ance in producing fancy radishes, especially with the button -mall varieties which are most largely grown. The seeds must be -ectly distributed in the row to avoid crowding, a most prolific -e of misshapen specimens. About 10 or 12 pounds of seed -erally are used to the acre of closely spaced rows. The correct of sowing and even distribution assume double importance when remembered that the cost of thinning is prohibitive with this of radish. For most of the early varieties under average con- -one a stand of about one plant to the inch, never more than is satisfactory. Rows may be a foot apart, or several inches, -e or less, as may be most convenient.

Another factor of great importance in obtaining well shaped of uniform size and maturity is even covering of the seed at the -rect depth, about a half inch under ordinary conditions. It is -ntial, therefore, that the soil be prepared very smoothly and that opening shoe and coverers of the drill be adjusted with precision. The long-type radishes require slightly more space than the small -nd or oval kinds, and the larger growing winter radishes should -e 2 to 4 inches between plants in the rows.

Varieties.—Wide differences exist in the varietal characteristics radishes. Factors of especial importance to the commercial -wer are: size, color, solidity, and shape of root; size and vigor -he top; and adaptation to season of growth. It is most conven- to group radish varieties according to relative earliness and the -sons in which they are usually grown.

The quickly-maturing varieties are ready to use in 14 to 30 under good conditions. They are employed for early spring -nting and are easily grown at that season. They are commonly

grown at other seasons and produce well even in hot weather w[hen]
soil and moisture conditions are perfectly favorable. After at[tain]ing the best edible stage the roots of these varieties rapidly be[come]
spongy or pithy, especially in hot weather, and flowering sl[talks]
develop very quickly when the days are long.

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FIG. 112.—White Icicle, one of the most attractive radishes.

Scarlet Globe is the most important, quickly-maturing va[riety]
and it is the leading market radish in nearly all parts of the cou[ntry].
It is globe to olive shaped, bright scarlet in color, and mild, te[nder]
and crisp at the proper market size of ¾ to 1 inch. The crop [ma]tures in 3 to 4 weeks from sowing. Some growers produce [this]
variety throughout the season from successive plantings. Sp[ecial]
small-topped strains have been developed for greenhouse use. *C[ri]mson Giant* is similar but larger in size, a few days later, and doe[s not]
become pithy and bolt to seed so quickly. *Sparkler* or *Scarlet [Tur]nip White Tipped* is a popular early, white-tipped, crimson ra[dish]
often somewhat flattened in shape. *White Icicle* is a popular [long]
sort that is preferred to the round red types on some markets. [It is]
a profitable variety for light soils that will produce straight, [long]
white roots. It is the earliest of the long radishes and of exc[ellent]
quality. *Early Long Scarlet Short Top* is popular among m[arket]
gardeners.

Summer varieties of important rank are *White Strassburg* and *...rtier*, long white and red varieties, respectively, that are planted ...nsively for summer and fall crops. *Giant Stuttgart* is a late ...mer and fall variety with fairly large, top-shaped white roots. ...ut 35 or 40 days are required for market stage.

Winter varieties of importance are *Chinese White*, *Chinese ...e*, and *Black Spanish* which grow comparatively large and can ...tored in the same manner as other root crops. About 60 days ... required for their development.

Marketing.—Prompt harvesting is necessary to secure the early, ...ckly-maturing varieties before they become pithy, oversized, and ...gent. Only a few days may pass between attainment of market... stage and development of inedible condition. Radishes usually ... graded and bunched as they are pulled. Three to 10 are bunched ...ether in accordance with market customs. They are tied with ...rse twine or rubber bands. It will pay to discard wormy, mis...ped, pithy or oversized specimens, and to wash the roots thor...ghly before marketing. Ice in the packages will check the ...dency for the leaves to turn yellow.

Insects and diseases that may attack radishes are the same as ...se affecting cabbage, turnips, and related crops.

As a rule the most serious pest is the root-maggot. The earliest ...ing plantings may escape; windy sites are unfavorable for the ...-laying activities of the flies, and rotation and relatively large ...ntings reduce the proportion of infestation.

In small plantings, applications of a solution of 1 ounce of cor...ive sublimate, or a suspension of 1 ounce of calomel in 10 gallons ... water may be necessary. By using the latter material, danger of ...rning the foliage will be avoided where flea beetle injury is pre...ent. Refer to the topic Cabbage Maggot (p. 212) for details.

HORSE-RADISH (*Armoracia rusticana*)

History and importance.—This extremely hardy perennial of ... mustard family had its origin in eastern Europe. Later it became ...turalized in Great Britain, growing wild along streams, in mea...ws, and in moist, uncultivated soils. It has become one of the ...st important condiments. Large supplies are used during the ...ler parts of the year. In this country horse-radish often is seen ...out the farm premises and it is grown commercially to a limited ...ent. In some of the trucking regions sizeable fields of it may be ...n, and many market gardeners find a small planting profitable.

Uses.—The roots are fleshy, whitish externally and pure white ...hin. When properly grown they are long, nearly cylindrical and ...branched for several inches. The flesh is very pungent and biting

to the taste. When ground or grated it is treated with vinegar a used mainly as a relish with oysters and meats. Grated horse-rad soon loses its stinging properties when exposed to the air, so t sealing in jars is necessary for its preservation.

Soil.—Very light soils or heavy clays should not be used for t crop, but deep, fertile, sandy loams provide ideal conditions. Libe and constant supply of soil moisture is essential for best resu although good drainage is important. There must be no deficier in humus if large roots are desired.

Fertilizing.—Rotten stable manure is valued in the culture horse-radish. It should be plowed under rather than used as top-dressing, because surface applications are thought to encour branching on the upper portion of the roots. Commercial fertiliz also can be used profitably, 4-8-8 without much manure and 4-1 with plenty of manure, and they usually should be plowed in horse-radish. Early, deep, thorough preparation of the soil is fun mental.

Propagation.—The plant is propagated from root cuttings m from the laterals removed when the roots are trimmed or prepa for market. The longest pieces produce the largest roots. Th generally range from 5 to 8 inches in length and average ab ¼-inch in diameter. As these roots are nearly uniform in gir they are cut square at the top to denote which end is to be plan uppermost; the lower end is always cut obliquely. They should tied in bundles of convenient size, packed in sand, and stored in cool, moist place until wanted for planting. Some growers prefer bury in well-drained soil. Crowns may be planted, but they p duce a large number of small, branched roots which are unsatisf tory for grating or grinding.

Planting.—The roots generally are planted obliquely or p pendicularly, with the tops 3 to 5 inches below the surface, althou many growers prefer to place them horizontally. Furrows about inches apart and of the proper depth should be made first if the c is to be planted alone, and the roots then are placed 18 to 24 inc apart, with the tops all pointing in one direction. The direction the tops, in case of horizontal planting, usually is alternated ev 4 to 8 rows so that the direction of cultivation with respect to p tion of the crowns can be the same in all rows. In this way tendency of the cultivator to pull the sets is avoided.

Horse-radish can be planted with a spade or crowbar betw early cabbage plants and often is intercropped with radishes, be or early lettuce plants.

Cultivation.—When horse-radish is not intercropped the trac —or horse-drawn weeder can be used weekly until the plants several inches high. Thereafter frequent cultivations are advisa

intil the plants close the rows and they should be managed to con-erve the moisture supply as much as possible. Size is gained rap-dly during the cool, fall season.

Stripping.—To overcome the tendency of the horse-radish plant o produce many branches the practice of stripping is employed by nany of the best growers. The description that follows is by Nissley, New Jersey Extension Bulletin 43).

"In order to produce the finest market roots, free from side roots, growers ractice lifting them at least twice during the growing season. The first lifting done after the largest leaves attain a size of from 8 to 12 inches. The soil is aken away from the set, care being taken not to disturb the end of the set or he roots formed thereon. The crown end of the set is then lifted and all but he best root is removed. Any small roots which have started from the crown r set are rubbed off, with the exception of those at the extreme tip. The set is hen returned to its normal position, and the ground replaced. Four to six reeks later the sets are again lifted, and any side roots which have developed re again rubbed off, the sets being replaced and covered the same as before. more or less clean root is thus assured, provided the stripping has been thor-ugh. A woolen glove or rag is desirable for this operation, because the side oots are hard to rub off with the bare hand."

Harvesting and storing.—As the roots are perfectly hardy, hey may be left in the ground all winter if desired and generally re harvested after the other root crops. Extensive growers dig he crop late in the fall, then bury it in the ground or store it in root ellars or pits until sold. It is customary to plow one furrow away rom the row, then to turn out the row of roots with an ordinary low adjusted to run as deeply as possible. To avoid covering them he roots are gathered from each row as plowing proceeds. Proper torage conditions, as in pits (p. 207), prevent the roots from hriveling and drying out. Yields will vary considerably, averaging rom 2 to 4 tons to the acre.

Preparing for market.—The roots are stripped of all small branches, trimmed at crown and bottom, and cleaned thoroughly. Slatted cylinder types of rotary washing machines are ideal. The mall, straight trimmings, about the thickness of a lead pencil, are aved, trimmed as described earlier, and stored as sets for planting he next crop. Many growers who sell direct to the consumer or o retail stores make larger profits by grating the roots and selling he product in glasses or jars rather than by disposing of the fresh oots.

Insects and diseases.—The recommendations that follow also re by Nissley:

"The horse-radish root rot is the only serious disease affecting this crop. There are two types of rot: In the more common one the inside of the large root ecays within ¼ to ½ inch of the outside walls. The second type begins with he outer rind and usually continues until the root is entirely destroyed.

"The storage pits are the most common source of infection but the dis does occur in the field. Clean seed can be obtained by cutting the ends of set-roots, throwing out the diseased ones, and dipping in a 1:1000 bichloride mercury solution for 15 minutes before planting. Plant only strong and heal roots.

"The most common insect enemy of the horse-radish is the horse-radish beetle which acts like other flea beetles. It appears when the sprout is bre ing through the ground and while it is still small.

"No effective remedy has been discovered for the control of this bee Treatments with a mixture of powdered arsenate of lead and sulfur have b known, however, to control the attack of the beetle to such an extent t plants were able to show a better growth than those not receiving this treatme

"For detailed information regarding this pest, see United States Departm Agriculture Bulletin 535—Horse-radish flea beetle, its life history and distri tion."

The harlequin cabbage bug may become serious on horse-radi Control measures have been discussed (p. 236).

CELERIAC OF TURNIP-ROOTED CELERY
(*Apium graveolens*, var. *rapaceum*)

Culture.—This umbelliferous plant belongs to the celery speci The root is the edible part. It is used for flavoring, as a salad, a for cooking, as other root crops. The roots vary in size from 2 to inches. They may be stored during the winter under the same co ditions as for beets or turnips. This vegetable is of minor impo tance in America.

Its culture is practically the same as for celery. The early cr may be started under glass and transplanted to the open when the is little danger of severe frosts. As the plants are not blanched, le space is needed between rows than for celery when banked wi earth. Seed for the late crop is sown in the open at the same ti as late celery and transplanted where the crop is to mature. S thrown over the roots in the fall will whiten and protect them un early winter, when they may be stored as other root crops.

TURNIP-ROOTED OR HAMBURG PARSLEY
(*Petroselinum hortense* var. *radicosum*)

Turnip-rooted parsley, which is of minor importance, produc edible roots that are used mainly in soups. The cultural metho described for carrots are suitable for this crop.

SALSIFY (*Tragopogon porrifolius*)

Importance.—Salsify, also known as the "oyster plant" "vegetable oyster," because of its flavor, is not commonly used. T plant is native to southern Europe, biennial, but grown as an annu

or the roots which may be left in the ground all winter without danger of injury from freezing. The roots are long, tapering gradually, and seldom more than 2 inches in diameter at the top. They are cooked like parsnips, used in stews and soups and sometimes in salads.

Culture.—Culture is practically the same as for parsnips. Seeds are sown in the open ground as early as possible in the spring, in rows one foot or more apart, and the plants are thinned to 3 or 5 inches. The soil should be deep, rich, and friable; sandy loams are preferred. Rigid thinning is essential to secure roots of good size. The seeds (botanically fruits) are much elongated and for this reason are difficult to sow evenly with a drill. Market gardeners ordinarily dig some of the roots in the fall and store them like parsnips. The remainder of the crop is left in the ground all winter and removed in the spring as soon as the frost is out of the ground.

XIX

PERENNIAL CROPS

Since plantings of the perennial crops produce over a period years the location should be outside the regular rotations, or near edge of the garden. Because of the comparatively permanent nat of the planting the soil should be selected carefully for adaptabil and the initial state of fertility should be favorable.

ASPARAGUS (*Asparagus officinalis*)

History.—Asparagus was appreciated as a vegetable by Romans about 200 B.C. Cato's directions for its culture would se fairly well today. Wild forms are found along the shores of Mediterranean Sea, in Western Europe, and in southern parts of British Isles, Russia, and Poland. Formerly the tender shoots the wild plants were sold at the market places of many countr Asparagus has been grown as a vegetable in America since the ea settlements were established.

Plant characteristics.—There are about 150 species of genus asparagus, which belongs to the lily family. Although shoots of a few other species and the roots of some are edible, *paragus officinalis* is the only one that has found a prominent pl in the vegetable gardens of the world. The hardy, branching, her ceous plants are 3 to 7 feet high. The numerous filiform branchl and the very fine delicate foliage make the tops valuable for deco tive purposes. While the plant is herbaceous, the root stock is p ennial. Root extension is practically horizontal, although many the crowns gradually rise nearer the surface of the ground each s ceeding year. The fleshy cylindrical roots, about a quarter inch diameter, provide overwinter storage for the elaborated mater from which early spring growth and the crop are developed. older roots eventually become hollow and die and are replaced new roots. Asparagus is normally dioecious, that is staminate pistillate flowers are borne on different plants.

Importance.—Asparagus is regarded universally as one of most important vegetables. California, New Jersey, South Caroli Georgia, Illinois, and Maryland lead in its production. The cro grown commercially to a smaller extent in nearly all parts of country. Asparagus may be found on the city markets from winter until August, and the forced crop is available to some ext

roughout the winter. To a limited extent in California, irrigated lds are dried for a rest period and then watered for fall production. early everyone enjoys this vegetable, which formerly was regarded a luxury.

The flavor and quality of asparagus may be preserved remark- ly well by canning or quick freezing, and immense quantities are rown for these purposes.

Climatic requirements.—The asparagus plant seems to be well lapted to all temperate regions. The crop has been grown success- lly in all parts of the United States where the winter is sufficiently vere to render the plants dormant for an adequate period, but ields are less in the far South. While the most extensive planta- ons are usually at low altitudes and near large bodies of water, eir success is probably due more to ideal soil than to climatic in- uences, because equally good results are secured under favorable land conditions.

Soils.—Asparagus is grown successfully on a great variety of oils. It is generally admitted, however, that the deep, rich, moist, andy loams—not too sandy—provide the best conditions. Silt ams, and even clay loams that are not inclined to bake, are very atisfactory when of good depth. Muck soils, in which the water able does not rise too high, produce excellent crops of asparagus nd are used extensively in producing the canning crop. Stony soils re very objectionable; they interfere seriously with the growth of he shoots, prevent thorough tillage, and are especially annoying to he harvester. Whatever the texture of the soil, asparagus demands igh fertility, plentiful organic matter, good drainage, and an abun- lant and constant supply of moisture. Light soils are especially im- ortant for the growing of blanched asparagus, because it is very ifficult to produce straight shoots and also to ridge and cut the crop n heavy or stony land. Very porous soils, with southern, southeast- rn, and southwestern exposures produce earlier but often smaller rops. Increased earliness in some localities may be a disadvantage n account of greater losses by hard frosts or competition with other istricts.

Varieties.—The Washington strains of asparagus are in most ommon use today. They were developed for rust resistance but ave other desirable characteristics, such as high yield, a tinge of urple, and tall growth before branching.

Mary Washington is not quite so rust resistant as *Martha Wash- ington* but suffers no appreciable loss under ordinarily severe rust onditions. The shoots are large and branch high so that it is pos- ible under favorable conditions to cut very long spears with buds till tight. This strain is early, productive, and has become the tandard for planting nearly everywhere.

It is generally accepted that *Palmetto*, *Reading Giant*, C
Colossal, and *Argenteuil* are practically identical varieties tha
been listed separately for years. These were the most exte
planted varieties previous to the introduction of the Wash
strains. Locally selected strains still are planted to some exte
some of them are excellent for the conditions prevailing.

Coker's Pedigreed Seed Co.
FIG. 113.—Well graded bunch of Mary Washington asparagus showing desirable tight heads.

Producing Seed.—Many successful asparagus growers
seed from their own plantations. As a rule, seed gathered in th
from producing plantations of high grade parentage is very sat
tory. Others consider it worth while to practice more careful
tion.

Large size and superior market quality count more than any
else in securing remunerative prices, and prolific budding o
crown promotes large yields. These objects, therefore, shou
paramount in the mind of the grower who would produce hi
seed. Vigor of stock also is essential and it is an advantage to
parent plants that produce moderate number of large spears
than a great many small spears. The prospective plants fo
production are studied carefully. The observant grower final
cides upon certain specimens that approach his ideals. They ar

m rust, with large shoots that outnumber those of the average nt. To be certain of getting seed from the most productive nts, some of the most promising specimens may be marked and nbered and the yield of each weighed for a season or two. It is t as important to choose high-grade male plants as it is to choose best female plants. There may be several female plants to one le and they should be in close proximity to each other to insure rough pollination. A stake should be driven at each plant to rve as a mark the following spring. The spears from all other nts in the field are cut and marketed as usual and only two or ree stalks are retained on each breeding plant.

To eliminate interference with cultivation some growers remove number of outstanding plants in the ratio of one male to four fe- ales, divide the crowns into four or more pieces, and replant in a ecial seed production bed. There the selected plants are available r seed production year after year. Contamination with pollen om neighboring plantings that are cut regularly and cleanly is oided by permitting the first stalks in the selected bed to grow d set seed.

When the berries are red the stalks are cut and hung until the uits are fully ripened. Then they are stripped from the plants, ashed in a pail, and cleaned by successive washings. The heavy eds sink, while the light ones float and are poured off with the shells d the pulp. Further selection of large, plump seed should be ade by screening with a mesh of proper size. Exacting growers ten separate and discard half the seed, using only the larger seeds r planting. Seed of excellent quality is available to the discrimi- ating buyer also among commercial sources.

Growing roots or crowns.—It is universally conceded that a rong one-year-old crown is superior to older crowns. The roots of o-year plants are often seriously mutilated when dug, and the unger plants become established more quickly and grow more pidly. The best cultural conditions must be provided to produce rong crowns in a single season.

The richest soils should be selected for this purpose, and the seed ould be sown in the spring as soon as the ground can be prepared. s the seed germinates very slowly, an early start is important in rder to have the benefit of a long season, and a few radish seeds n be included to mark the rows. If hand-wheel hoes are to be sed, the rows should not be less than 18 inches apart, while for orse tillage 30 inches is not too much space. A pound of plump, e-h seed should produce enough plants to set an acre and 3 to 4 or pounds of seed will plant an acre of propagating bed. Spacings of to 4 inches apart in the row are required to produce the most vigor-

ous crowns. Accurate adjustment of the seed drill is extre portant. It is a common mistake to crowd the planting.

The depth of covering over the seed should not be more inches. To hasten germination the seed can be soaked in 3 or 4 days, keeping the pan in a warm room, preferably a F., and changing the water twice daily. The seed is spread dry just enough for drilling, and is sown at once in moist so soaking is of little effect.

If the stand of seedlings is too thick, thinning is advisal operation must be completed within a few days after th emerge, however, or the stalks will pull away from the root feat the purpose of reducing the number of plants. Thi paragus seedlings is, at best, an unsatisfactory and tediou that should be avoided by correct sowing. Plate-type seede drop a single seed in one place, are most desirable. The m ough tillage should be given the nursery plat throughout th Nitrate of soda generally can be employed effectively as a t ing at intervals during the summer. One hundred pounds to may be applied each time, sowing broadcast or along the ro

A less common and more expensive method is to sow during the first half of August, mulch the bed over winter, a plant the little crowns early the next spring, 2 inches de inches apart in conveniently spaced rows. Very fine, lar can be produced by this method.

Asparagus may be propagated also by dividing the crown method, however, is not satisfactory and seldom, if ever, is p by commercial growers.

The young roots may be dug in the fall and stored in the of root crops or left in the ground over winter. On light so mulch of strawy manure or other litter is advisable unless c covers the land over winter. Early spring lifting and imme planting is preferable as the wilting or development of mold that may occur in storage is most likely to reduce the v stand of the plants.

Crown selection.—In seed production, the importance o ing parent plants and large, plump seeds has been emphasi lection again plays an important part when crowns are ch the new plantation. Rigid grading at this point is one of t important factors in establishing a uniform and heavy-p plantation. The following suggestions for grading the roo Tiedjens, Whitcomb, and Koon (Extension Leaflet No. 4?, chusetts Agricultural College):

"The best type of root has a number of large buds rather loosely d over the crown and above the average size for the lot. The largest ro good distribution of buds, two or more clusters to the crown, should be

...ving long, spindling roots or those with a large number of small buds should be discarded since they will produce plants with small ... small crowns having one cluster of large buds are probably low yielding plants. If there are two lots, and in one the roots average larger, it ... to take the largest of each rather than to take them all from the lot of ...s. That does not mean that good, small roots should not be planted. ...e roots are small because of the season, they should be used, provided ...hers are rejected. At least 25 per cent of the roots should be discarded. ...re grown under crowded conditions, it is impossible to select 50 per ...t all that can be done is to throw out undersized culls. Such roots ... yield the maximum because good roots cannot be distinguished from ... when grown under crowded conditions."

...wing versus buying crowns.—Asparagus growers almost ...y find it an advantage to grow rather than buy crowns. ...ce of seed can be controlled, proper culture can be given the ..., careful digging and grading are assured, withering in ... or transit can be eliminated by lifting and planting the ...n the spring, and the danger of receiving two-year culls is ... In addition the expense usually is less when the grower ... the crowns he requires. A few growers specialize in the ...ion of first-class crowns for sale. The best of these usually ...00, 125 or more pounds to 1,000 crowns.

...e versus female plants.—The results secured by several in...ors indicate that male plants produce a larger number and ... total weight of spears but that female plants yield larger ... The most common and probably the best commercial prac... ...o disregard sex, which is not shown until the second year in ...ld, and carefully select the crowns as explained under crown ...n.

...l preparation.—When it is realized that the asparagus plan... ...to last 10 or 15 years or longer, it is evident that too much ... and care cannot be given to the preparation of the soil. ...t is common to use land that was planted to other vegetables ...vious year, some of the most successful growers prefer to ... the asparagus planting with clover sod, and the crop has been ...to thrive remarkably well when planted on land which has ...n alfalfa for several years. An excellent practice in prepar... ... land for asparagus is to plow the sod in midsummer and plant ...grass, millet, oats, or barley. In turn the green manure is ... or disked into the soil very late in the fall. Large applica... ...f stable manure, when plowed in as a mat just before plant... ...e inefficient. It is better to apply the manure in one or more ...ahead to the crops of the preceding year so that it may be ...throughout the soil before the asparagus is planted.

...rennial weeds, such as thistles and quack grass or witch grass,

should be eradicated before asparagus is planted. They can be exceedingly expensive pests in the established plantation.

The soil should not be plowed deeper than its natural depth, but there should be complete pulverization to the full depth of the plow furrow. To accomplish this a disc or a cutaway harrow can be used to advantage before plowing. This treatment is especially important when sod lands are to be planted. After plowing, the harrows should be employed until the ground is in perfect condition.

Lime requirement.—Asparagus is very sensitive to acidity and thrives best in neutral or nearly neutral soils. It is perhaps the most lime loving vegetable plant. On many soils in humid regions 2 tons or more to the acre of ground limestone are required to produce the proper reaction for asparagus. If the soil is very acid it should be limed a year before the roots are set and again in the course of preparation for planting, or, if that is impossible, part of the amount should be spread and harrowed in before plowing. Applications of commercial fertilizers can be only partially effective in soils which are too acid. The suitable range of pH as suggested by different authorities is 6.0 to 6.5, or even 6.5 to 7.0.

Manuring.—Stable manures formerly were applied in large amounts by nearly all asparagus growers. Now most growers find manures too expensive to apply heavily, and many have abandoned their use, especially after the plantation has been set. An economical and satisfactory program under most conditions is to build up a large store of organic matter with stable or green manure, or both, in the years immediately preceding the establishment of the plantation and thereafter to depend upon discing the tops into the soil for organic matter and applying commercial fertilizers for nutrients. Farmers who keep livestock or can purchase manure cheaply, however, usually make annual applications of manure to excellent advantage. The usual procedure is to broadcast the manure any time from fall to spring and to disc it thoroughly into the soil early in the spring, or apply it at the end of the cutting season if that is more convenient.

Fertilizing.—Earliness, high quality, and large size are the important factors in securing remunerative prices, and liberal and intelligent fertilizing bears a direct relation to each of these requisites. The gardener expects a great deal of his asparagus plants; he wants them to produce salable shoots for two months or more and then recuperate sufficiently to yield a good crop the next year. Other factors than the mere production of shoots must be taken into account. The enormous root system and the tons of tops renewed every year must be supported. Again, growth of both shoots and tops should be very rapid, and, consequently, there must be no shortage in supply of quickly available nutrients. Very few garden

crops can be fertilized as heavily as asparagus and yield a profit on every dollar expended.

Probably the most widely suitable fertilizers for asparagus are 4-8-8 or 5-10-10 without manure and 5-10-5 with liberal applications of manure; or the equivalent in more concentrated mixtures or separate fertilizing materials. There is a question, however, regarding the value of phosphoric acid and potash applied on the surface of asparagus beds, especially on heavier soils. Evidently the rate of penetration of phosphoric acid into such soils is so slow that relatively little benefit is derived unless the fertilizer can be deposited in the root zone, which is difficult or impossible to accomplish without serious injury to the crowns and roots, and the same is true of potash to some extent. In preparing to plant a new bed, it may pay, in certain soils, to plow down a fertilizer with a high ratio of phosphorous and potash, or superphosphate alone on soils naturally well supplied with potash.

Rates of application normally range from 1000 pounds an acre the first year to 1500 or 2000 pounds for bearing plantations. As a rule, one-half the fertilizer is broadcast and disced into the soil early in the spring and the rest is applied in the same manner as soon as the last cutting has been made. On heavy soils it probably is safe to apply all the complete fertilizer before cutting begins.

In addition, one or two top-dressings of about 300 pounds of nitrate of soda or 200 pounds of sulphate of ammonia, or the equivalent, are likely to be profitable. Some growers prefer to make one top-dressing during the latter part of the cutting season and a second in August. The skilful grower observes the growth of the plants and varies the fertilization during the season and from year to year.

Some growers have used cyanamid very successfully to furnish nitrogen for the asparagus crop and at the same time to utilize the temporary sterilizing effect to kill weeds. The manufacturer's recommendation follows:

"Shortly after the cutting begins and the weeds in the row are about 2 inches high, apply 300 to 400 pounds of cyanamid per acre in a band 12 to 18 inches wide directly on top of the row. Cultivation into the soil is not necessary and no harm will be done to the young asparagus tips.

"Near the end of the cutting season when the next crop of weeds is about 2 inches high, apply 300 to 400 pounds of cyanamid per acre on the row."

Common salt formerly was applied extensively to asparagus beds. Applications heavy enough to kill weeds are expensive and may injure the crowns. Any need for chlorine is met from that supplied by the muriate of potash contained in the fertilizer. The

practice of salting asparagus beds has been discontinued practic[ally] everywhere.

Planting distances.—Relatively wide planting is gaining fav[or]. It is conducive to the production of large, fancy spears and cre[ates] a plantation that will produce profitably over a longer term of ye[ars]. Spacings of 24 inches in rows 5 feet apart may be considered [opti]mal for well-grown and selected crowns planted on good aspara[gus] soils. Eighteen inches by 4 feet may not be too close under s[ome] conditions, especially if the bed is not to be kept very long. [Close] plantings set about 1x3 feet usually prove short-lived and prod[uce] only small, second-grade spears. Six feet between rows is not [too] much space under exceptionally favorable conditions, and distan[ces] of 6 or 8 feet are required when high ridging is practiced to prod[uce] white shoots.

Planting.—Fall planting is practiced occasionally but e[arly] spring planting is universally regarded better. After the gro[und] has been plowed and thoroughly harrowed, furrows must be ope[ned] preparatory to setting the crowns. If the land is steep enough [for] erosion to occur, the furrows should run with the contours.

The depth of the furrow should not exceed the natural depth [of] the soil. The crowns are set 6 inches to 1 foot deep, but a depth [of] 8 inches usually is considered sufficient, and less depth is an adv[an]tage in heavy soils. Certainly, the crown never should be se[t in] the subsoil, where the fleshy horizontal roots will fail to find no[ur]ishment or proper physical conditions. The chief advantage of d[eep] planting is to get the crowns beyond the reach of tillage im[ple]ments. Some asparagus crowns grow toward the surface, oth[ers] grow horizontally, and a few grow downward. Enough of th[em] rise toward the surface so that shallow planting would soon lead [to] considerable damage by tillage implements. On the other ha[nd], very deeply planted asparagus is less vigorous in growth and p[ro]duces later, smaller crops. In the production of green aspara[gus] unnecessarily deep planting increases the length of the relativ[ely] unpalatable, unsalable white underground portion of the spear. [This] wasted growth needlessly dissipates reserves stored in the roots.

The trenches for planting can be opened with an ordinary mo[ld]board plow, making a round or two in the same furrow, or in [one] operation with a middle breaker or double moldboard plow. If [the] soil in the bottom of the trench is hard it should be loosened [by] means of a subsoil plow, a "rooter," or a single narrow steel o[r] shovel plow standard. A hand shovel may be used to open secti[ons] into which the soil has fallen or to finish the furrows in better f[orm] for planting.

It is better not to set the crowns flat in the bottom of [the] trench, but spread the roots over a very slight mound of fine

d then cover the crown with about 2 inches of fine moist soil. e ground should be well firmed over the fleshy roots. The anter may accomplish this with his feet as he rises and proceeds the next plant. Inexperienced growers often make the mistake covering the crowns too deeply at first, thus smothering or exhausting the small shoots in their attempt to reach the surface. No ore soil should be put into the trench until the shoots appear. hen soil is gradually worked in, mainly by cultivation. By midmmer or fall the furrows should be entirely filled.

Establishing asparagus fields from seed sown where the plants e to remain is not a practical method among commercial growers.

Intercropping.—Lettuce, beets, peas, beans, onions, early cabge, or any quickly-growing vegetable can be planted between the paragus rows the first season, but great care should be exercised prevent interference with the culture or the growth of the more portant and permanent crop.

Cultivation.—Tillage should begin promptly after the new bed planted. Care must be exercised to prevent breaking or covering e young plants. One-horse cultivators are especially useful at the st cultivations of the young bed and during the summer when e plants in the permanent bed have grown too large to admit the o-horse riding cultivator. Cultivation should be frequent from rly spring until it becomes impossible to get between the rows. eeper stirring than is necessary to kill weeds is objectionable. ailure to control weeds wastes fertilizer and adds to the draft on serves of soil moisture.

Tillage before and after the cutting season.—In established elds the disc harrow should be used to break and pulverize the rface soil as soon as the ground is dry enough in the spring. Manure, fertilizer, or lime may be worked into the soil at this time, at the time of harrowing immediately after the last cutting of the ason has been made.

Harrowing in old fields will injure some of the buds, but the enefit usually is so great that the operation is justifiable. It should e noted, however, that careless, unnecessarily deep discing, esecially on very light soils, may nearly ruin the crowns. Under ch conditions it may be advisable to set the gangs rather straight nd to disc just enough to cut up the old tops and manure and then nish the working with the spring-tooth harrow.

A special practice that may be advisable when long green asaragus is to be produced from very deeply-set roots is to remove art of the soil over the rows. This can be done with the moldboard low or middle breaker without injury by careful adjustment of he clevis and depth-regulating wheel. The partial uncovering must e completed early, however, to avoid destruction of growing buds.

On the other hand, some growers of green asparagus under w conditions believe that the decreased expense for controlling v when a certain amount of ridging is practiced more than o the slight loss in yield. Some hoeing usually is necessary. A growers employ the horse-drawn weeder during the cutting se If it is used during the middle of sunny days, when the spear not so rigid, very few shoots will be broken or injured.

The control of weeds in the asparagus planting cann neglected without making reductions in yield certain. Late weed growth, however, or even annual varieties of green ma crops, such as oats sown in late summer, may be of benefit in ing organic matter provided the fertilizer application is incre to supply both the asparagus and the other crop.

Disposal of tops.—The tops should never be disturbed they actually are dead, not merely yellow. Translocation of food materials from the tops to the storage roots proceeds p cally as long as life remains in the stalks.

Opinions differ concerning disposal of the tops. Cutting burning all the crop and weed refuse have the advantage of des ing many beetles, weed seeds, and rust-infected stalks. T will be easier in the spring, and there will be no coarse residues w may cause crooked spears. On the other hand, working al residues into the soil adds a substantial amount of fiber which be an important consideration if manure is unavailable and soil bakes and is deficient in organic matter. The best practice be determined by circumstances.

White and green asparagus.—When rows of asparagus ridged the shoots must make additional growth before they the light, and, if cut as soon as the tips appear above ground product is known in the produce trade as white "grass." If the is level and the spears are cut at the surface of the ground, or slightly below, the product is known as green grass, which far greater demand and commands materially higher prices. A siderable quantity of white asparagus is grown for the cann but the green product is gaining in favor even for that purpose comparison, the white portions of spears are relatively tough the green portions are tender and of superior flavor and nutr value; the spears diminish in diameter after they reach the su and it takes more to make a bunch of green asparagus than of w the rows may be planted much closer for green grass, thus ten to equalize the advantage of diameter in case of white grass; grade white spears can be grown only in sandy soils while the no such limitation with the green product and larger yields probable on moderately heavier soils; in growing green shoot stalks are more exposed to the attacks of beetles. Regardle

points for or against each type, green shoots are decidedly more ular and are grown much more extensively.

The harvesting season.—There is increased tendency to cut a short period the second year. Without doubt the quality of crowns that were set, the conditions of culture the first year, the consequent size and vigor of the plants are more important age in determining how soon and how long the bed may be ately. If the spears average about ½ of an inch in diameter, ing to 4 weeks may be permissible. The third year the season be extended, perhaps to a length of 6 to 8 weeks if the planta- exhibits great vigor. Under practically no circumstances is it itable in the end to cut longer than 8 weeks, in the North, that ntil about the market days preceding July 4. With the most rable circumstances, alternate halves of a strong plantation be cut each year until the middle of July. The ultimate profit uestionable. The production of the shoots is an exhaustive cess, and it is possible to reduce materially the vitality of the nts by cutting too long. When the shoots begin to show weak- it is certainly time to stop cutting. If an old bed is to be ndoned, cutting can be continued in the summer as long as the p pays for the labor.

Cutting the spears.—A few growers remove the shoots with the d, breaking them neatly with a quick, sidewise jerk and with- leaving a stub to decay. This is not easy to accomplish with- breaking some of the spears too high, but it does eliminate the ger of careless or inexperienced workers injuring the buds or wn.

The nearly universal method is to insert the special asparagus fe alongside the shoot to the required depth, move the handle ward to form the cutting angle, and sever the spear with a short st. If new laborers are engaged it is time well spent to uncover efully a bearing crown to demonstrate the buds and spears in ious stages of development and show the possibilities for doing ary. Careless cutting, especially needless jabbing several times ut a single spear, may cause serious losses in potential yield.

The depth as well as the length of cutting must be regulated ording to market demands. As a rule the spears are cut when y have grown 6 or 8 inches above the ground. White grass must cut just as soon as the tips appear. Green grass usually is cut htly below the surface of the ground to permit neat bunching and mming of the full length of green shoot, or there may be a com- mise by cutting 3 or 4 inches below the surface. Even 1 or 2 hes of white at the base of the spears, however, is a serious handi- in many markets.

When the weather is warm, cutting must be attended to daily.

and, occasionally, twice daily to avoid loss from the developm[ent of] overgrown, "woody" or "feathered" spears. To eliminate t[he] for insects and to encourage the continuing production of [the] every shoot, marketable or otherwise, is removed at each c[utting] unless some are reserved for seed purposes or for lure pla[nts] which poison is placed to destroy beetles.

Fig. 114.—Convenient asparagus buncher. Simple devices of three narrow bo[ards] nailed in U-shape are also used. One end is board, the other open, and the [sides] are sawed to make slots for the tape.

Ingenious organization of the harvesting operations may [result] in considerable economy of labor. A common procedure is f[or] workers to cut with one hand, gather the spears in the other [and] place them in piles as they collect handfuls. Each cutter ha[ndles] two rows and places the spears in the middle between his p[air of] rows and those of his neighbor. Thus the asparagus from 4 [rows] accumulates in one middle space where another worker gath[ers it] in trays, flat boxes, or baskets. Another method is to put a h[andful] in a box and move it to the adjoining row for the next cutter.

At each step in handling, care is necessary to prevent bre[aking] the spears or damaging the tips. Exposure to sun and dryi[ng] should be reduced as much as possible.

Yields of 1,500 to 3,000 pounds of marketable asparagus

are about the average of good growers, although 3,000 pounds are secured with the best plantations at their prime.

Grading and packing.—Asparagus shoots may be washed before or after bunching. Although both methods have their advantages, cleaning may be done more thoroughly before bunching. Conveyer washers often are used. Careful grading is of great importance. Most growers make three sizes, while a fourth class (culls) makes it possible to have each size of perfect grade. Standard specifications of spear diameter are: Very large—¾ inch and over, Large—$\frac{9}{16}$ to ¾ inch, Medium—⅜ to $\frac{9}{16}$ inch, and Small—$\frac{5}{16}$ to ⅜ inch.

Special devices known as bunchers are in general use. The bunches vary from 6 to 15 inches in length and are usually 4½ inches in diameter, weighing from 1 to 3 pounds. Nine-inch bunches are popular on eastern markets. The number of stalks to the bunch varies from one dozen to two or three dozen with the size.

The bunches must be tied firmly near the top and near the bottom. Red tape, ¼ to ½ inch wide, is in general use, because it is most attractive. Rubber bands are preferred by some growers. No. 30 is often used in making one pound bunches. Their advantage over tape lies in greater rapidity of bunching and in keeping the bunches tight and firm, whereas the least wilting causes looseness in bunches tied with tape.

All sorts of packages are used for local marketing but growers who specialize in the crop pack in the well known asparagus crates. The bottoms of the bunches usually are placed on damp sphagnum moss to reduce wilting, or the lower half or two-thirds of the bunch is enclosed in parchment paper or cellophane. In either case a sheet of waxed paper is useful in the bottom of the crate to retain moisture.

Keeping asparagus.—Asparagus is one of the most perishable vegetables. Although it may remain fairly attractive in appearance for several days, the quality deteriorates with great rapidity at the usually warm temperatures of the cutting season. To assure satisfactory quality it should be in the hands of the consumer within 12 to 24 hours after harvesting, unless good refrigeration is provided. When it must be kept overnight, or for a day or two without refrigeration, the general practice is to stand the bunches in shallow pans containing about ½ inch of water. Even then, if kept in a warm place, the length of the spears increases, flavor depreciates, and a bitter, woody condition develops. The rate of deterioration can be retarded greatly by immersing the bunches almost to their tips in ice water, or they can be held fairly close to the freezing point in refrigerators.

Crooked spears.—These are a source of loss to every asparagus

somewhat by cutting all unmarketable as well as marketable spears during the harvesting season, and by burning the tops in the fall, after they are brown and lifeless, but before they become brittle.

RHUBARB (*Rheum Rhaponticum*)

History and importance.—Rhubarb is indigenous to eastern Asia. It belongs to the buckwheat family, *Polygonaceae*, and is a popular herbaceous, very hardy perennial which is grown in nearly all home and market gardens. In a few localities it is grown rather extensively. It often yields good returns for a short time in the spring but most markets are soon oversupplied and prices drop very low.

Soil.—Deep, rich, sandy loams provide ideal conditions for rhubarb which, however, may be grown successfully on all types of soil in deeply fertile condition. Because the plants require an enormous amount of moisture, the soil should be bountifully supplied with organic matter. Irrigation may be profitable on droughty soils. Warm types of soil or those sloping to the south are desirable when earliness is the chief consideration. The earliest marketings usually command the best prices.

Propagation.—The plants are propagated readily from seed sown under glass or in the open, but, as only a small percentage of the plants produced in this way are true to type, division is the method ordinarily employed.

A piece of root containing a strong eye will grow and, under favorable conditions, produce a good plant in one season. Many growers, however, prefer to divide the old clumps into only 4 to 8 parts. Thus several eyes and a considerable amount of root are retained intact and the new sets grow more promptly into large vigorous clumps that yield heavily the spring after planting.

Varieties.—*Victoria* is a popular vigorously growing variety that produces very large stalks of somewhat green color. *Linnaeus* produces more slender, attractive red stalks. With the best culture it is a profitable market variety and is preferred for the rich color it imparts to the dish. *Macdonald* represents one of the more successful efforts to develop a large, vigorous variety of high color. In general the highly colored varieties are inferior in vigor and yielding capacity but are more attractive.

Planting.—Fall planting is sometimes practiced, but spring planting is preferred. Early planting is important to make the division while the roots are fairly dormant and because the plants need the entire growing season for their full development. The most common distances for planting are 3x4 or 4x4 feet. Planting in checks is a great advantage as it permits cultivation both ways to

dislodge docks, grasses, or other strongly rooted perennial weeds. The saving in hand labor by check rowing is greater with rhubarb than with any other crop. The sets are planted in furrows of convenient depth, usually with the crowns slightly below the surface level, and are covered with two or three inches of soil. Sometimes the clumps are divided at the close of the spring market season. Unless droughty weather follows, fairly good growth may occur on deep, moist, fertile soils.

Fertilizing.—In the fertilizing of rhubarb the grower should be guided by the fact that early, heavy yields of big stalks can be secured only when the care of the plants the preceding year has enabled them to build up great reserves in the large, fleshy roots. The program of liberal fertilization described for asparagus is quite applicable in the culture of rhubarb (p. 366). The lime requirement of rhubarb, however, is comparatively low.

Stable manures are valued very highly for rhubarb because they increase the moisture-holding capacity of the soil, reduce the rate of evaporation when applied as a mulch, and furnish nutrients over a long period. Some growers apply 10 to 25 tons of manure and 1000 or more pounds of 4-8-8 fertilizer annually.

Readily available nitrogenous fertilizers are particularly effective when applied very early in the spring. Additional applications may be made at intervals during the cutting season, and again at its close unless a complete fertilizer is used at that time. Rhubarb is a gross feeder that is not likely to be overfertilized.

Cultivation.—As soon as the soil can be worked in the spring it should be stirred rather deeply to work in manure or complete fertilizers. Subsequent tillage should be frequent but no deeper than necessary. Some hand hoeing or weeding generally is necessary to remove weeds that escape the cultivator. Infrequent cultivation often permits pernicious, perennial weeds to become established, after which it may be prohibitively expensive to eradicate them. In such cases yields are reduced and the life of the planting is shortened.

The seed stalks which appear should be broken out promptly to encourage vegetative activity.

Duration of the planting.—Rhubarb plants will persist and produce for a great many years. Generally the best profits cannot be realized in plantings more than 5 to 7 years old. After that time the stalks usually become smaller and the roots should be divided and reset.

If it is desired to retain the bed in its original location, much the same effect can be accomplished by plowing or spading away parts of the old crowns to stimulate the remaining eyes to renewed growth and subsequent production of large stalks.

Some growers lift the roots a year or two before they begin to decline in vigor and force them during the winter, as explained on page 496. The largest and finest forced rhubarb, however, is produced from one or two year old roots of great vigor.

Marketing.—Harvesting begins as soon as the stalks have attained a length sufficient to satisfy the markets and continues for about 8 weeks. The largest stalks are pulled, and no attention is paid to the smaller ones. At no time should the plant be deprived of more than about three-fourths of its leaves. It is not customary to make long continued or extremely heavy pullings until the third year from planting. Harvesting in any year should not continue until the plants approach exhaustion.

Rhubarb is essentially a spring and early summer crop. Ordinarily the active season of marketing is late April, May, and possibly June. From 2 to 6 stalks are tied in a bunch. Red or blue tape adds considerably to the attractiveness of the product.

Insects and diseases.—Rhubarb is comparatively immune to serious ravages of insects and diseases. Ordinarily the gardener is not obliged to undertake control practices. **Crown rot** *(Phytopthora cactorum)* is a soft rot of the crown and lower portions of the leaf-stalks that may cause material loss. Preventive measures are to secure disease-free stock and to plant in uncontaminated soil. The recommendation has been made to disinfect dormant crowns by soaking for one-half hour in 1 to 1,000 solution of corrosive sublimate.

GLOBE ARTICHOKE *(Cynara Scolymus)*

The globe artichoke seldom is found in American gardens. The edible part is the globular flower head in the bud stage. Most of the commercial production is in California.

Culture.—The globe artichoke is hardy, but requires some protection during the winter in most northern sections. It is easily propagated from seed or suckers, or by division of roots. If the seeds are sown under glass early in March, and the young plants are pricked into pots before setting in the open, edible heads may be cut the first season. If the seeds are sown early in beds out-of-doors the plants should be set in the field the following spring. Some gardeners prefer to propagate from suckers, because plants from seeds show great variation.

This vegetable thrives in any rich, moist, but well-drained garden soil. The rows should not be less than 4 feet apart and the plants spaced 2 or 3 feet in the row. For the best results the plantations should not be retained more than two or three years; some growers keep them only one year. When maintained for more than one season, the old plants are cut back within a foot of the

ground in the late fall. Coal ashes to the depth of a foot are recommended as a winter mulch in cold climates and are considered preferable to straw which may be conducive to rotting of the crowns. The mulch is removed early in the spring. The number of the numerous suckers which arise is reduced to 5 or 6. Those which are removed can be used in planting new beds. The large buds are cut with an inch or two of stem just before they begin to open or flower. Liberal fertilization is practiced.

GIRASOLE or JERUSALEM ARTICHOKE
(*Helianthus tuberosus*)

Uses.—The Jerusalem artichoke was cultivated by the American Indians but is produced at present by few American gardeners. It is native to North America. Although the tubers, which constitute the edible part, are of high nutritive value, they are not relished by many people. They can be served cooked in the manner of potatoes.

Culture.—This vegetable grows as a weed, even in poor soil, but responds to liberal feeding. Sandy loams are preferred. Under favorable conditions the plants yield 500 or more bushels an acre. The tubers may be planted whole, or cut into pieces, in the same way that potatoes are planted. Planting very early in the spring is essential to heavy yields. The rows should be about 3 feet apart, and the tubers or cut pieces placed 15 to 18 inches apart in the row. As soon as the tops are dead the crop may be dug, or left in the ground all winter without danger of injury by freezing.

XX

PEAS AND BEANS

Peas and beans are widely popular. They are grown in every market garden, and vast acreages are planted for sh and for preservation by canning and freezing. Peas are a cool-season crop; beans are a tender warm-season crop. Bo legumes.

When grown as vegetables they scarcely can be termed so proving crops; however, they are considered easy on the lan desirable in the rotation. Beneficial effect often appears in th ceeding crop. When market peas, snap or green-shell bean grown, no part of the plant is removed except the pods and contents and, in such instances, an appreciable amount of or material is returned to the soil. It is notable that successive ping of either peas or beans often increases yields, althoug practice courts disaster by aiding accumulation of disease orga

PEAS (*Pisum sativum*)

History.—Peas are believed to have originated in Eth Mediterranean Europe and in Southwestern and Central Asia. origin is known to have been remote. Seed was discovered Egyptian tomb and Greek and Roman writers mentioned the Peas were first used extensively as dry cooked seeds. Garden as distinguished from field peas, were recorded in 1536 but common use began after 1700.

Young garden peas which are regarded by many as a surpa delicacy, the most delicious of vegetables, are of high nutritive v The advent of the mechanical huller, late in the last century the more recent development of shipping methods which con quality, have made both fresh and processed peas popular, around foods.

Climatic requirements.—Peas are very sensitive to heat thrive only in cool weather. For these reasons the large comm plantings are made very early in the spring. Plantings made the weather becomes settled and warm rarely produce satisfa yields. Almost invariably the first plantings yield most he and successive later plantings produce progressively smaller c

The North naturally provides the best conditions, althoug cellent results are obtained in the South when advantage is t

e cooler months. There must be ample rainfall to insure a full
Irrigation is essential in areas where rainfall is very deficient.
t weather the growth is retarded, insects and diseases become
troublesome, and pollination may be seriously hampered, caus-
ods to contain few peas. Unless the growth is very tender,
lants will stand hard freezing, although they sometimes are in-
when freezes occur after several days of good growing weather.
y the blossoms are injured by severe frost. Varieties differ in
ical and climatic adaptability (p. 384).

Classification.—Peas can be conveniently classified according
se: (1) Forage or green manure crops, (2) dry, edible seeds,
green-shelling peas for use fresh, or to be canned or frozen,
(4) edible-podded peas. Among these there are remarkable
commercially very important differences in plant and pod
acteristics, and in suitability to the different purposes and
rements of the crop. Many of the varieties or strains have
developed or have been found to be rather specifically suited
rtain conditions of use or culture and are poorly adapted to
r situations.

Green-shelling or garden peas, as indicated, may be intended for
fresh or to be canned or frozen. There is some overlapping of
but in general the varietal needs of commercial market growers,
ers, and freezers are so distinct that entirely different varieties
used for each purpose. Briefly, the market grower needs large,
ctive, dark-green pods with good-sized seeds; the canner must
varieties of simultaneous ripening habit and with vine and pod
racteristics well adapted to vining machinery; and, the freezer
s large-seeded kinds that thresh easily and are suited to the
ner of processing. Large-podded kinds as a rule can be picked
rapidly by hand, and peas that are not too dwarf in habit
rowth and have small or medium pods with blunt ends usually
le best in harvesting and vining machinery.

In the discussion that follows, detailed varietal descriptions have
been attempted because it may be more useful to consider the
eties by convenient groups, and all the meritorious names are
cely to be included. It is helpful to review the descriptions
d in the better seed catalogues. The inexperienced grower who
ects to make important plantings should seek recommendations
his experiment station and from outstanding seedsmen.

A summary (Wade, United States Department of Agriculture
rbook, 1937) of the principal varieties of green-shelling peas
ommon use at the present time includes:

Canning peas:
Alaska
Perfection
Surprise
Prince of Wales
Green Admiral
Yellow Admiral

Market peas:
Progress
Hundredfold
Giant Stride
Alderman
World Record
Gradus
Thomas Laxton
Early Gilbo
Dwarf Telephone
Stratagem

Canning varieties.—*Alaska* typifies the extra-early, sma podded, smooth-seeded varieties. Quality is low. *Surprise Eclipse* is practically as early with dimpled seeds of better qualit *Perfection* is somewhat later with wrinkled seeds of good qualit These are by far the most extensively grown canning varieties ar are available with resistance to fusarium wilt. *Prince of Wal (Green Giant)*, *Green Admiral (Fairbeard Nonparcil)* and *Yello Admiral* are of minor importance. There is an increasing trei toward canning the large-seeded, dark-green peas.

Market varieties.—*The early varieties* normally produce a cr ready for picking in about 60 days. The *Alaska* type of smal podded, smooth, and small-seeded peas is planted to a very limite extent for local marketing. The prices received are usually mu lower than for larger-podded, darker-green varieties which mature little later. *Mammoth Podded Extra Early* and *Laxton Super* produce larger pods and are included to some extent in many earl market garden plantings. Color is fair. The seeds are dimple or slightly wrinkled and the quality is not objectionably low whe the crop is produced before warm weather arrives and harveste promptly at the best edible stage. These varieties are semi-dwar about 20 to 36 inches in height of vine, varying with the variet and conditions of growth.

World Record, often called an improved *Gradus*, and *Thoma Laxton* are early, wrinkled-seeded varieties, maturing in about 6 days, with medium-sized pods of fairly dark color. The height c vine is respectively about 30 and 36 inches and the quality is goo and excellent. Nevertheless, these varieties have been displace to a considerable extent on the markets by the much larger-podde and darker-green peas which are also of high quality.

Progress (Laxton Progress) and *Hundredfold* are outstandin very dwarf varieties, 16 to 20 inches high, that produce exceptionall large and dark green pods of the type in greatest demand. Qualit is excellent. Progress is normally ready to pick in 60 or 62 day from planting and Hundredfold, which is slightly taller, a day or tw later. These varieties are superseding *Laxtonion*, *Blue Bantam*

Washburn-Wilson Seed Co.

FIG. 115.—Typical row-section showing Laxton Progress pea.

Peter Pan, and others of similar type. The best culture and fertilization and liberal supplies of moisture should be provided for these very dwarf and highly bred varieties to bring out their yielding ability which is remarkable in view of their small growth. Under adverse conditions they are unlikely to be as satisfactory as ranker growing kinds.

Second-early or midseason market varieties are slower in maturing, requiring about 70 to 75 days. Most of the best varieties for this season of maturity belong to the Stride group. The better known are *Giant Stride, Midseason Giant, Asgrow 40, Morse Market, Wyoming Wonder,* and *Stridah.* Some of these may be practically synonymous, or, again, there may be differences of a week or more in maturity and variation of about one-half inch from the characteristic pod length of about four inches. The peas are large, the pods are dark green, and the quality is very good. Growth is vigorous and length of vine ranges from about 2 to 3 feet. Morse Market is about intermediate between Progress and Stride. *Gilbo* is an excellent very large and dark-podded variety, very similar to Stride though a little earlier.

Stratagem or *Potlatch,* and *Dwarf Alderman* are among the

latest of the semi-dwarf varieties and, although formerly pop they are being replaced by the Stride type.

Alderman, which is superseding *Telephone*, typifies the varieties, 4 to 5 feet in height, that produce large, dark-green of unexcelled quality. Seventy to 75 days are required to a edible maturity and for best results the vines must be given sup Alderman, however, is widely planted without support.

These later varieties succeed best where the moderate temp ture and higher humidity of spring are rather prolonged and summers are cool, or where the transition to hot, dry weather ceeds slowly. For the same reasons, the very late varieties of which succeed well in England and under similar conditions where are very poorly adapted to the United States. Likewise, e planting is equally or perhaps more important with slow-matu varieties of peas to enable them to attain normal developmen vine and a full setting of evenly-filled pods before high temperat or drought interfere. In fact, second early varieties often suc better than late ones when planting is long delayed.

Peas for freezing at first were secured from among the be suited market and canning varieties. Various agencies are wor on the development of varieties especially adapted for freezin

Edible-podded peas, which are without a lining membrane

Washburn-Wilson Seed C

FIG. 118.—Characteristic pods of Stride, a popular type of second-early peas.

pods, are represented by *Mammoth Melting Sugar*, tall, and ...rf *Gray Sugar*. *Sugar Stick* and *Giant Butter* are thicker ...ed. The tender young pods are used in the same manner as ... beans. Sugar peas are appreciated in a few localities but are ...rally unimportant commercially.

Soil preferences and preparation.—Cool, moist, but well-...ned soil is essential for the largest yields. The sandy loams are ...erred, although good results can be obtained on any loose, fer... , well-prepared soil. Heavier soils are improved greatly for ... by the liberal addition of organic matter. Clay and silt loams ...used advantageously for any but the earliest plantings.

Fall plowing generally is advantageous because it permits earlier ...ting, particularly of large acreages. To facilitate clean harvest-... of the cannery crop with the mower, the surface should be ...hed as smooth and level as possible. Light rolling or cultipack-... often should follow drilling. Very weedy soils are especially ...ectionable for growing cannery peas.

Fertilizing.—When good sods, green manures or stable manures ...e been plowed under within a year or two, manuring for the ... crop is unnecessary. Fresh stable manures should not be ap-...d near the time of planting, but rotten manure formerly was used ...ly by market gardeners.

The main dependence today is upon commercial fertilizers. ...en peas are planted as early as they should be, growth begins ...ore nitrification is active. Typical practices are: 500 to 1000 ...nds to the acre of 5-10-5 or 4-12-4 broadcast and harrowed in ... early peas under market garden conditions; 300 to 500 pounds ...he same mixtures applied along the row by the band method for ...e-scale market growing; and 200 to 300 pounds of 4-12-4 or ...-4 drilled with the seed for cannery peas. Superphosphate alone ...he rate of 300 to 500 pounds to the acre may be most profitable ...oils that have been brought to a very high state of fertility with ...er manures or legumes.

In all cases of row-fertilization of peas the planter should be ...ipped to split the fertilizer stream and apply the material in the ... in bands (p. 111). Peas are extremely sensitive to injury. ...or stands often are caused by placing the fertilizer in the row with ... seed. However, 150 pounds to the acre usually can be drilled ...h the seed in moist soil without serious reduction in germination. ...ertheless, yields from the same amount of fertilizer nearly ...ays will be higher when the drill is equipped to place the fer-...zer about 2 inches from the seed and an inch lower.

The lime requirement of peas is not high, but very acid soil ...ditions should be corrected. Most recommendations suggest a ...ction not below pH 5.5 or 6.0.

Inoculation with nitrogen-fixing bacteria is likely to prove profitable unless the soil has produced within several years garden peas, field peas, or vetches that have borne nodules on the roots. Fresh commercial cultures are most convenient. (p. 89).

Planting.—For most purposes peas should be planted as soon as the ground can be prepared properly, ordinarily during April in the North, and not much later. Wrinkled varieties usually germinate successfully on well-drained soils even when planted as early as is customary with the smooth-seeded sorts. Several plantings may be made in quick succession to prolong the harvest. Even then there is a tendency for all plantings of a variety to mature at nearly the same time. Yields will be higher if the entire acreage is planted as early as possible, and dependence for succession is placed on the use of early, second early, and midseason varieties. Late plantings, those made after May 1 in the more populous areas of the North, rarely yield well, seldom more than half as much as earlier plantings.

The depth of planting must be determined by the character of the soil and the season of the year. For very early planting, shallow covering, probably with only an inch of soil or less, may be an advantage, although 2 to 3 inches would not be too much in very light soil as the season advances.

Planting distances depend upon the length of the vines, whether they are to be supported or not, and the purpose of the crop. When grown for the cannery, peas are sown with a grain drill usually with alternate holes blocked. When planting is for market, grain drills with some of the holes blocked, special multiple row drills, or hand sowing in furrows are employed as may be most convenient and economical for the conditions. Typical spacings between the rows are 18 to 24 inches for the very dwarf kinds; 30 to 36 for half-dwarf varieties, and 48 inches for the tall ones.

In planting for the cannery with the grain drill, about 3 to 5 bushels of seed are used to the acre; in rows 2 to 3 bushels are the usual amounts. It does not pay to economize on seed. Dwarf varieties sometimes are planted in paired rows about 8 or 10 inches apart with approximately 2 feet between pairs.

Cultivation.—Peas planted in rows must be cultivated to control weeds, but deep cultivation that may cause extensive root injury is to be avoided. When the crop is drilled, ordinary cultivation is impossible and weeds usually are smothered by quick development of a mat of vines covering the entire surface. In both methods the weeder sometimes may be used to good effect when the peas are only a few inches high and the weeds are tiny. Damage to the erect young vines will be slight on most soils if the weeder is used during breezy, sunny hours.

Supporting the vines.—When grown for commercial purposes

the low varieties generally are given no support. Even the tall varieties sometimes are grown on the ground with the rows 4 feet apart. In small plantings, brush stuck into the ground often is used. A neat, convenient method is to plant in double rows about 8 inches apart, and stretch poultry netting of the proper height between the rows. Another very good plan is to drill in single (or double) rows, drive strong end posts with lighter stakes between at intervals of 10 to 15 feet. Strands of wrapping twine are then stretched from stake to stake as close together as may be necessary to give the proper support. Any of these methods are prohibitively costly for

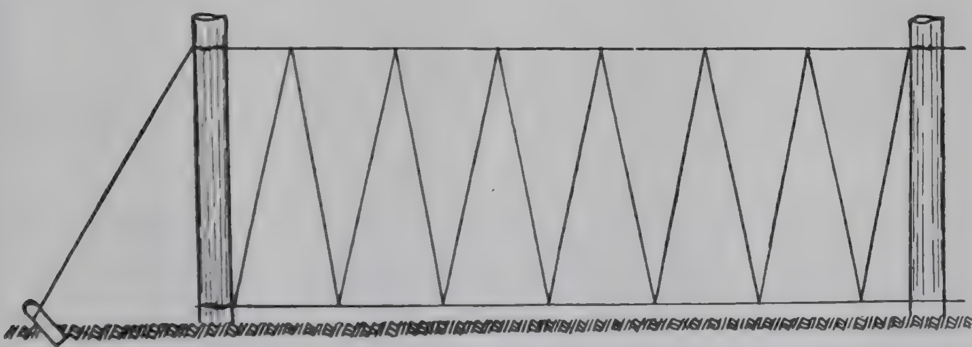


FIG. 117.—Inexpensive trellis for tall peas and pole beans, No. 10 or No. 12 wire at top and bottom, twine between. Similar construction with vertical cords, often without the lower wire, is commonly used for tomatoes trained to single stems.

extensive operations and really are unnecessary for most conditions because of the excellent dwarf and half-dwarf varieties now available.

Harvesting.—To combine the desirable factors of good yield and high quality, peas must be harvested just as soon as the pods become well filled. Delay of only one or two days when temperatures are very high often results in serious impairment of market condition or canning quality.

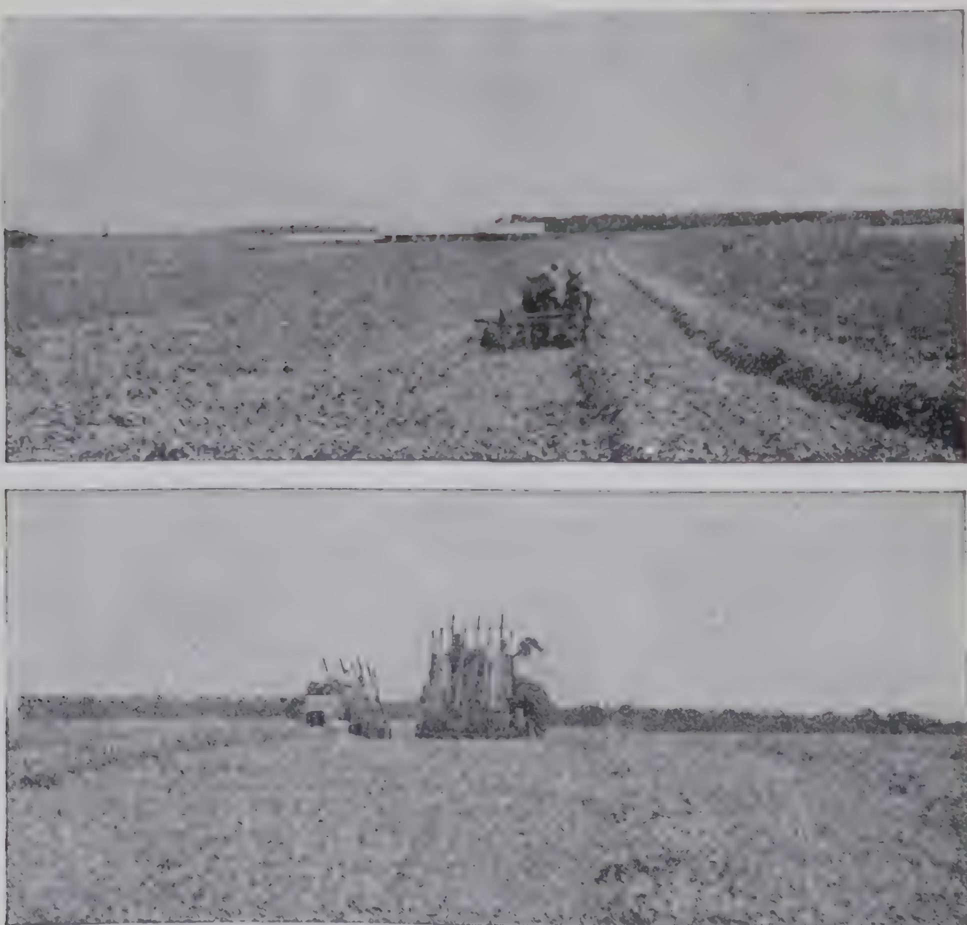
In harvesting for the cannery the peas usually are cut by means of mowers, equipped with special vine lifters and windrowers, and ordinary haying equipment is employed to load and transport the crop promptly to the viner stations.

Peas for market are harvested by hand, usually at two pickings, although one may be sufficient with a variety highly bred for simultaneous ripening and planted under conditions that permit very uniform emergence and development of the seedlings. Some varieties and conditions may require three pickings to secure the full crop at the well-filled but young and tender stage. As a rule the cost of picking market peas about equals all other costs of production.

Good but not exceptional yields of peas are about a ton to the acre as shelled at the cannery and 100 to 150 bushels in the pod.

Packing and marketing.—Peas are one of the most perishable vegetables and are particularly susceptible to injury by heating. In warm weather no effort should be spared to rush them to the packing house or cannery and there remove the field heat as quickly as possible, as suggested under Pre-cooling, and Use of ice (pp. 189, 190). Washing may be necessary if the pods have been muddied by dashing rains.

In packaging for local marketing, or whenever the period from packing to retailing is short, relatively small and well-ventilated packages, such as 16-quart baskets or hampers, may be used. For more distant shipment the preferred method is to pack the peas in paper-lined crates with liberal quantities of crushed ice. Fast transportation with refrigeration then assures delivery at the market without undue deterioration in quality or appearance.



Seabrook Farms

FIG. 118.—Machinery replaces hand picking in harvesting peas for canning or freezing.

Seed production.—Seed-pea growing is one of the largest seed-growing enterprises. Generally about 3 bushels of seed are drilled to the acre and yields, which are extremely variable, average about 15 bushels to the acre, with a net yield of about 12 bushels. Thus, an acre of seed-peas will supply seed for only about 3 acres of cannery peas or 4 acres of market peas. The industry is highly specialized, particularly in certain irrigated areas of the northwestern states and in California where relatively disease-free seed can be produced. As a rule, it is not profitable to save seed from your own crop in the East. Serious losses from seed-borne diseases may follow in certain seasons.

Insects.—The pea aphis *(Macrosiphum pisi)* is the only common insect pest of peas which may cause serious damage. Often large areas become infested and entire crops are destroyed when conditions are favorable for breeding. Early planting and overhead irrigation often are of some effect in preventing severe attacks.

Strong nicotine dusts are effective when properly applied. The following directions are Extension Service recommendations of the New Jersey State College of Agriculture, January, 1937:

"In dealing with pea lice, it has been found that the treatments should begin when there are 50 or less lice to 10 feet of row. A 4 per cent nicotine dust is recommended for this insect, using 30 pounds or more of dust per acre when the temperature is above 70° F. If the temperature is below 70° F. the acre dosage should be increased to 40 or even 50 pounds per acre. If the temperature is as low as 60° F., the application should not be made. In applying the dust a trailer of muslin, 20 to 30 feet long, should be used. This trailer should have a drop in front and at the sides and should be weighted down to prevent the wind from blowing it about. The nozzles should be set rather low, pointing slightly downward and to the rear at an angle of about 35°. In some seasons more than one application may be necessary to hold the lice in check if migration from the clovers and alfalfa has not been finished." (p. 175).

Dusts and sprays of finely powdered derris or cubé root (p. 167) have proved very effective, and of relative long-lasting effect, against the pea aphid. They are effective at lower temperatures than nicotine.

The pea weevil *(Bruchus pisorum)* does not breed in dried peas but may winter there and be planted with the seed peas the following spring, when eggs are deposited on the pods and the larvae burrow into the green peas. Control is secured by treating infested seed peas with carbon disulphide (p. 181).

Diseases.—The first step in combating pea diseases is to choose resistant varieties as far as they may be available. This is the only effective means of controlling *fusarium wilt.* The grower should consult frequently the seedsmen who specialize in peas, as new disease-resistant developments continually are being introduced.

Seed should be secured that is as free as possible from seed-

borne diseases, which, in the case of peas, include *Ascochyta blight*, *bacterial blight*, and several others. Clean seed is most likely to be procured from the inter-mountain section of the West and along the Pacific Coast.

Protective seed treatment (p. 22) with about 2½ ounces of red copper oxide, zinc oxide or Semesan and 1¼ ounces of microfine graphite to the bushel nearly always results in better stands by protecting the seed against decay organisms that may cause damping-off or root rots. In a few instances germination has been reduced. The conditions which favor injury apparently are very dry soil, deficiency in soil organic matter, and possibly unusual susceptibility of a few varieties. The powdered graphite is included to facilitate the flow of seed in drilling and to offset the tendency of copper oxide to cause clogging and breaking of the seeds. Copper oxide treatment should be omitted with seed that has been inoculated.

Rotations, not including peas, beans, vetches, clovers, or alfalfa oftener than once in 3 or 4 years, are effective against the organisms of several diseases, but are without avail in case of wilt which persists in the soil almost indefinitely.

Well-drained soil minimizes the effect of diseases, such as *Rhizoctonia root rots*, that are favored by excesses of moisture.

Early planting avoids, to a degree, the root rots caused by the *Aphanomyces* which are most active at fairly warm temperatures, especially when there is much rainfall.

Proper fertilization, in fact all the factors of soil management which promote strong and rapid growth, is especially important in the culture of peas. With these, the crop may attain a relatively advanced and less easily injured stage before the diseases favored by warm temperatures become very active.

Deep and clean plowing-under of the vines immediately after harvest hastens destruction of several pea-disease organisms and reduces the possibilities of dissemination by surface drainage, wind, or mechanical means. Manure from animals that have been fed pea vines should not be returned to land where that crop is to be grown.

BEANS

Beans of several genera and many species are native to various parts of the world. One or more kinds are grown extensively in nearly every land. In tropical countries certain species grow luxuriantly and produce abundantly, while in cold agricultural sections other species or varieties are grown with success. Beans constitute one of the most important groups of crop plants and are widely

planted to provide food for man and domestic animals and to improve soils.

COMMON BEANS (*Phaseolus vulgaris*)

This is by far the most important species grown in the United States. The term beans in ordinary usage includes the several classes of common, or kidney, beans used in dry-shelled, green-shelled, or "snap" condition. The American Indians in pre-Columbian times grew beans extensively and often interplanted them with corn in the manner sometimes practiced today.

Classification according to use.—The expression "snap" beans is applied to beans in the tender young stage when the pods are eaten. This class is known also as string beans, although practically all varieties of present importance are stringless. Snap beans are one of the most valuable crops grown by home and market gardeners and by truck farmers for shipment and canning.

"Green-shell" beans are shelled and used just before the seeds become ripe and hard. They are quite popular in some localities.

"Dry" or "field" beans are produced in the fully matured and dried stage. They usually are grown and classed as a field crop, and have an important rank. Field beans generally are divided into kidney, marrow, medium, and pea types on the basis of length and shape of seed.

Beans of many varieties may be used in any of the three stages, but, commercially, only specialized varieties are planted for each purpose.

Varietal groups.—In addition to classification according to use, beans may be divided into dwarf or bush and pole or climbing groups. Each of these groups includes greenpods and waxpods, which in turn may be flat, round, or intermediate in cross-section of pod.

As a whole, bush beans are slightly hardier than pole beans and produce their entire crop in about one or two pickings. Pole beans, when systematically harvested, continue to bear during comparatively long periods and this is an important factor in their popularity with home gardeners. Most commercial growers prefer bush beans because of their concentrated harvest and because the expense of poles is eliminated.

As an average the market varieties of bush beans produce a crop in about 50 days and the pole beans in about 70 days, with various varieties several days earlier or later.

The necessity of adaptation to the purpose of the crop and to environmental factors has been mentioned. With snap beans, the market preference in many places is for the green rather than the wax varieties and it may be for either flat or round pods. The

higher quality round pods are gaining in favor. For the cannery round-podded beans with light colored seeds generally are demanded.

Varieties.—The number of varieties is especially multitudinous. A list of some of the more important varieties of beans in the several classes follows. Bush varieties named include none but stringless types.

Bush varieties of garden beans:

Greenpods:	Bountiful; early flat pods fair-good quality
	Stringless Black Valentine; early, thin-walled, round pod, fair good quality
	Stringless Greenpod; second early, fleshy round pod, good quality
	Tendergreen; second early, fleshy round pod, very good quality
	Stringless Refugee; late—70 days, fleshy round pod, good quality, extensively planted for canning
Waxpods:	Pencil Pod; early, fleshy round pod, very good quality
	Brittle Wax or Round Pod Kidney Wax; second early, fleshy round pod, good quality
	Sure Crop; second early, flat pod, fair to good quality
	Refugee Wax; second early, round pod, good quality, popular for canning
Green Shell:	French Horticultural

Pole varieties of garden beans:

Greenpods:	Kentucky Wonder, Scotia
Waxpods:	Kentucky Wonder Wax, Golden Cluster
Green Shell:	Horticultural or Speckled Cranberry

Field or dry shell beans:

Wells Red Kidney, Michigan Robust Pea, Perry Marrow, White Kidney, Yellow Eye or Improved Yellow Eye

Environmental relationships.—Varieties of common beans exhibit considerable difference in their power to withstand heat and cold. Seeds of some varieties germinate much more successfully than others in cool, moist soil. Some are more tender to frost than others. There is great variation in length of time required to reach maturity. Certain types are especially susceptible to injury by hot, dry weather, others by excessive moisture in the soil or in the air. None of the common beans will escape more than a light frost. Prevalence of specific diseases varies widely with locality and climatic conditions. In selecting a location for specialized production of any kind of beans careful study should be made of environmental relationships.

Soil selection and preparation.—Soil requirements are not exacting, except that good drainage is essential. Moderate fertility is satisfactory. Beans are grown successfully on many types of soil but early crops of the garden varieties are produced most readily on soils that warm quickly in the spring, sandy soils and sandy, gravelly

shaly loams. Southeastern exposures are also advantageous for arly crops. For later production of snap or dry beans it is likely hat costs for fertilizers will be less and that yields will be higher ith moderately heavy silt or clay loams. Very compact or easily rusted soils are unsatisfactory.

Clean plowing-under of sods, manures, and trash in the early pring is important for the earlier plantings in order to destroy eeds by pre-planting harrowings, and to reduce losses from the seed naggot (p. 398).

Rotations.—In trucking and market gardening, beans may be vorked into the system of cropping at almost any point, provided ufficient time is allowed to attain marketable size. As beans must ot be started until the ground is fairly warm, there is often opporunity to grow early spring crops, such as green onions and radishes, before planting beans. Later snap beans are commonly planted fter early crops of lettuce, spinach, beets, carrots, cabbage, strawberries, and potatoes. Then, as time of the succeeding harvest may permit, the land is given to suitable quickly-maturing fall vegetables, uch as spinach, turnips, and radishes, or it is seeded with a covercrop.

Snap beans for the cannery and field beans are grown largely n rotation with ordinary farm crops. Three or four-year rotations ordinarily are permissible. Where dry rot caused by fusaria is troublesome and susceptible varieties must be planted, the growing of beans more frequently than once in six years may result in serious osses.

Fertilizing.—The suggestions for fertilizing peas (p. 385) generally are applicable in the culture of beans. Beans, however, usually do not respond to liming unless the soil is fairly acid. They are ranked low or medium in lime response; hence, lime usually is applied before the more sensitive crops in the rotation, perhaps clover, cole crops, celery, onions, peas, or spinach. Hill applications of rotted manure as well as fertilizers frequently are made in planting pole beans.

Planting bush garden beans.—If earliness is an important factor growers usually are willing to take some risks in getting an early start. The first planting may fail to germinate if the soil remains cold, or it may be killed by frost, but the grower probably will be well rewarded if it escapes. Extensive planting should at least await normal "corn planting time" for the locality, usually about 10 days before danger of frost is past. Succession planting of early varieties may continue until about 8 weeks before killing frosts are expected; that is, until about the last of July over a wide range in the northeastern states. Weekly or more frequent plantings are required to produce a continuous supply of snap beans in the best stage.

Beans usually are planted with corn drills equipped with bean plates. Grain drills, with part of the feeders blocked, and special multiple-row bean drills are used largely by extensive growers. Walking stick planters are efficient and popular in small gardens.

Common spacings are 24 to 36 inches between rows. With most varieties the beans should be spaced to provide a stand of plants 2 to 4 inches apart in the row. Thick planting may be practiced in early spring to help assure a good stand when germination is poor, and also in late summer to produce a dense crown of foliage that will protect the beans from light frosts. Fifty, 60, or 75 pounds of seed to the acre are common rates of planting.

On account of the habit of germination, in which the large, heavy cotyledons must be lifted above the surface, more soil than is necessary to assure a supply of moisture should not be used in covering beans. Ordinarily a cover of two inches of soil is ample; an inch or less is likely to be enough early in the season on moist loams, and three inches may not be too deep in dry sandy locations. Extremely shallow covering is objectionable if the large weeder is to be used over the young plants because many may be loosened.

Inoculation of the seed with suitable nodule bacteria usually is recommended when beans are to be planted where the crop has not been grown previously.

Planting field or dry-shell beans.—Early planting is not recommended, as wet, cold weather may stunt the plants, cause an uneven start and, consequently, a lack of uniform maturity. It is better to wait until the ground is thoroughly warm and there is little danger of damaging weather conditions. The kidney group may be planted earliest, followed by the marrows, and then the pea varieties. Spacing distances between rows range from 24 to 34 inches, with 28 inches the most popular. Some investigators believe the largest yields are obtained when the beans are planted 4 to 6 inches apart, although the usual distance is from 2 to 4.

Depth of planting should be regulated by the character of the soil; in heavy soils 1½ inches are ample, while 2 to 3 inches are not too deep in lighter soils. For planting, one-half bushel of the smaller beans to the acre is the most common allowance, although some farmers prefer three-fourths of a bushel; from 4 to 6 pecks of the kidney varieties are used for an acre.

Field beans usually are planted with grain drills. Either 9 or 11-tube drills may be employed. The operation is explained by the Michigan Station (Bulletin 259, p. 91) as follows: "One of the best machines for planting beans is the ordinary 11-drill grain seeder with 7-inch spaces between the tubes. Stop up all the tubes except the 2nd, 6th and 10th and let the drill wheel follow in its own outer wheel mark instead of in the last drill mark, as in sowing grain.

This will plant three rows at a time, 28 inches apart, which is about the proper distance. In planting the larger varieties of kidney beans, a bean attachment or special bean drill should be used. Some makes of grain drills have attachments for planting beans." Press wheels on the tubes are valuable to secure uniform depth of covering and an even stand. Field beans sometimes are grown in hills, but drills are favorable to larger yields.

Planting and supporting pole beans.—Pole beans may be planted in drills and supported by any convenient means but they are more generally planted in hills 3 x 4 or 4 x 4 feet apart. Four to six seeds are planted in a hill and later thinned, if necessary, to a stand of 3 or 4 at a pole. As a rule the hills are raised slightly to provide drainage and the poles are placed before planting. It is customary to erect the poles in sets of 3 or 4, leaning the tops together and tying them. For stability, the bottoms are pushed well into the ground. One pound of seed plants 100 to 150 feet.

Some gardeners use woven wire fence to support pole beans planted in drills. Another plan is to plant and then brace fairly heavy posts at the ends of the rows with lighter posts at intervals of 20 feet, the posts extending 5 or 6 feet above ground. A No. 10 wire is stretched over the tops of the posts, another near the ground, and the two wires are connected in a zigzag manner with twine (p. 387).

Cultivation.—If hard rains occur, causing the soil to bake before the seeds have germinated, the crust should be broken by the use of a weeder. This tool is used also to some extent after the plants are up. Some of the plants may be destroyed, but this is not objectionable if the stand is very good. The least damage will be done if the weeder is used in the middle of the day, when the stems and leaves are not so rigid. Crusts in the garden may be broken with a rake.

Clean tillage is essential to large yields. Weeds must be controlled to conserve both fertility and moisture for use of the crop and to assure the full circulation of air which helps keep certain diseases in check.

As the bean is a shallow-rooted plant, deep tillage should be avoided for it results in detrimental root pruning. Narrow teeth or shovels, and sweeps, are best adapted to the cultivation of this crop. In the culture of field and garden types on a large scale, riding or tractor mounted cultivators commonly are employed. When the plants are small, shields can be used, if necessary, to prevent covering them. Culture should be nearly level until the last cultivation, when slight ridging can be practiced to support the plants.

To avoid unnecessary spread of disease beans should not be cultivated when the plants are wet from dew or rain. Timely and skil-

ful cultivation will entirely eliminate hand-hoeing or weeding under most conditions.

Harvesting.—Garden beans must be picked by hand and a great many pickers are required when the crop is grown on a large scale. Availability of workers must be considered in planning the crop. Pickers often are paid by the basket or pound. With diligent supervision a field pack, suitable for marketing, usually can be secured. Many of the largest growers repack all the crop, however, by passing the beans over wire mesh conveyors, where the draft or suction of a large fan eliminates leaves and dirt, and watchful inspectors remove diseased or oversized beans. Thus a uniform and dependable pack is assured. After heavy storms washing may be necessary, but it should be avoided if possible. In any event timely action is required to harvest snap beans during the brief period after the pods reach satisfactory size and before they become full-grown with prominent seeds and fibrous flesh. One to three pickings may be required, depending upon variety and circumstances. Although beans are less perishable than peas, prompt handling to reduce wilting and heating and refrigeration in long transit are necessary to assure bright appearance and good quality on the market. Average yields are about 100 bushels to the acre but many good growers regularly secure double this amount. The crop generally is packed in bushel hampers in the South and in bushel or half bushel baskets in the North.

Green shell beans are picked after the beans become large but before the pods and seeds are dry. They usually are marketed, shelled, and packed in either pint or quart berry baskets.

Field beans formerly were harvested by pulling, but the machines now employed cut the roots of the plants just below the surface. To avoid excessive losses from shattering, harvesting should begin when most of the pods are fully matured. After the crop has cured a few days in windrows or small piles in the field, it is stored in barns in the manner in which hay is handled, and later is threshed, preferably with special bean threshers. Average yields are about 700 pounds to the acre.

Seed and seed production.—Small quantities of seed may be saved from vigorous and healthy plants. Commercial seed beans are produced mainly in western regions where disease is less prevalent and conditions are favorable for curing. The most disease-free seed usually originates in parts of California and the northwestern states, particularly Idaho and Colorado. When it is considered that bean anthracnose and bean blight, two of the most widespread and destructive enemies of the crop, as well as several other diseases, may be introduced with the seed, the importance of procuring healthy seed is apparent. This is almost impossible to produce East

of the Mississippi River. Under no circumstances should the grower accept seed visibly affected with disease.

Insects.—The Mexican bean beetle (*Epilachna corrupta*) is the most widespread and destructive pest of the crop. The beetles, about ⅓ inch in length, oval, yellowish to brownish with black spots, and the light yellow, spiny larvae are familiar. Definite control is readily obtainable. Proper application involves thorough coverage of the underside of the leaves where the eggs are deposited and the larvae feed. The first application should be made when the eggs begin to hatch, or earlier if abundance of adults results in injury. Two or three treatments are likely to be required. On snap beans or on other beans sold in the pods neither arsenicals nor fluorine preparations, which may leave objectionable residues, should be used after pods begin to form.

As a rule, economical control can be secured by two or three applications of arsenicals, the last to be made as blossoming begins. If the work has been done thoroughly the population of beetles will be very low and the amount of poison on the foliage probably will protect the crop until it is picked. Magnesium arsenate is less likely to injure the foliage than is calcium arsenate.

Formulae that follow are from Cornell Extension Bulletin 206 by Crosby and Chupp:

"SPRAY FORMULAS

Use 100 gallons per acre

Magnesium arsenate	3 pounds
Water	100 gallons

Add either 3 pounds casein spreader, or 3 pounds flour paste, or 3 quarts skim milk, and ½ pound of hydrated lime.

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	3 pounds
Hydrated lime	9 pounds
Water	100 gallons

DUST FORMULAS

Use 30 pounds per acre

Magnesium arsenate	20 pounds
Hydrated lime	80 pounds

If magnesium arsenate cannot be obtained, use the following:

Calcium arsenate	15 pounds
Hydrated lime	85 pounds"

Rotenone dusts and sprays (p. 167) are so effective against the bean beetle, safe from risk of foliage injury, and free from danger of objectionable residues that many growers now employ them exclusively in combating this insect.

Sulphur is a desirable diluent in preparing rotenone dusts for

use on beans because it reduces the attacks of leaf hoppers and red spiders.

The seed corn or bean maggot (*Hylemyia cilicrura*) often causes serious losses by attacking the germinating seeds and the seedlings before they emerge from the ground. As the adults prefer moist conditions for egg-laying, early plowing and fitting are advisable so that the surface may be dry when the flies become abundant, and planting should be delayed somewhat during a cold late spring. The attractiveness to the insects of soils containing decaying vegetable matter at the surface also deserves consideration in endeavoring to evade this pest. Relatively shallow planting to encourage quick development may avoid much injury.

The green clover worm (*Plathypenascabra*) sometimes occurs in troublesome numbers and the slender, light green caterpillars riddle the foliage. Ordinarily they will be controlled by arsenicals or rotenone applied in combating the Mexican bean beetle. For snap beans in the pod stage rotenone preparations or nicotine-soap sprays can be used in standard strength.

Flea beetles and **Aphids** occasionally demand control. See Chapter X for control of these and of **Weevils** which may seriously damage beans in storage.

Diseases.—Preventive measures are the only practical means of controlling the diseases of beans. The use of clean seed, resistant varieties when available, and rotation and sanitation should never be neglected. Treatment for seed-borne diseases and spraying are ineffective. **Anthracnose, Bacterial blight,** and **Mosaic** are bean diseases of major importance.

Anthracnose (caused by *Colletotrichum lindemuthianum*) is most familiar as black, sunken spots on the pods. When present in the seed or soil it may under favorable conditions kill the young plants by attacking the cotyledons or rotting off the stems at the surface of the ground. Later any crop that may be produced is likely to be rendered unfit for sale. Anthracnose is one of the most common and destructive bean diseases. It spreads rapidly during moderately warm, showery weather. At such times spores may be disseminated widely by dashing rain, surface drainage, and the movement of animals or tools through the field. Fortunately the casual organism does not survive long in the soil so that rotation and the planting of clean seed enable the careful grower to reduce his losses from anthracnose to a negligible amount. Development of resistant varieties is proceeding, particularly with field beans.

Bacterial blight (caused by *Bacterium phaseoli et. al.*) appears most conspicuously as brown blotches on the foliage, girdling of the stem at a lower joint, and as small irregular, water-soaked-appearing spots on the pods. The disease is not apparent in the seed but com-

monly is seed-borne. Control measures recommended for anthracnose are applicable in combating blight.

Mosaic (caused by a virus) produces characteristic mottling of the leaves with irregular light-yellow areas. The virus lives over winter only in the seed and is transmitted from plant to plant by insects, abrasion of leaves against one another, or any means of transferring the sap. In general, the market varieties of snap beans are fairly resistant, and resistant varieties have been and are being developed in the canning and field types.

Rust (caused by *Uromyces appendiculatus*) may cause considerable losses during prolonged damp, rainy periods with cold nights, usually during the latter part of the season. The disease is not seed-borne. It appears as pustules which may become numerous enough to defoliate the plant. Fungicides are ineffective. There are great differences in relative resistance and susceptibility of varieties. Most of the dwarf snap beans are fairly resistant, and resistant varieties of field beans have been developed. Kentucky Wonder pole bean is very susceptible, though rust-resistant strains are available.

Dry root rot (caused by *Fusarium spp.*) attacks the root system, thereby stunting the plant and reducing yields. It is most active in hot weather and in heavily limed soils. A six-year or longer rotation, avoidance of contaminated manure from animals that have been fed bean straw, deep plowing-under of refuse, shallow cultivation to conserve roots after the disease appears, and liberal fertilization are recommended. Several varieties are fairly resistant.

Rhizoctonia may cause important losses in warm, wet weather. Selection of well-drained soils and use of long rotations are advisable.

Powdery mildew (caused by *Erysiphe pologoni*) often is destructive in the Southeast. In severe cases it spots the pods badly and defoliates the plants. The disease develops most seriously with rainy fall and winter weather. Control has been secured with 2 or 3 applications of sulphur-lime dust, 75 per cent sulphur and 25 per cent lime, at 10 to 14-day intervals. Sulphur sprays also are used.

Baldhead usually appears to greater or less extent soon after the seedlings emerge from the ground. The "head," or stem above the cotyledons, is broken off leaving the young plant without a growing tip. The stump may grow for a time but the plant is ruined as a producer. The injury is most commonly attributable to injury to the embryo of the seed in threshing. Hence, the grower should avoid lots that appear to have been damaged in threshing. Injury is least when threshing is accomplished without excessive speed and the crop is not extremely dry. Baldhead is caused to a lesser extent, as a rule, by disease organisms and insects such as the seed corn maggot.

LIMA BEANS *(P. lunatus and P. limensis)*

Lima beans, which are of American origin, are an important crop both as dry and green shelled beans and for canning and freezing.

Culture.—All varieties are very tender. They will not germinate well if planted before the soil is warm, and the pole varieties require a relatively long season. Spacings between rows are about the same as for common beans, but 6 to 12 inches should be allowed between plants in the row according to type and variety. Warm, preferably sandy soils or sandy loams of good physical condition and fertility are required to produce large crops. Fertilizers usually are applied more liberally than for common beans. A top-dressing of nitrogen during the growing season often will increase yields, particularly with the large-seeded bush varieties on porous soils. In general the bush limas respond favorably to the liberal use of nitrogen. In one test 16-8-7 fertilizer gave better results than 9-8-7. To avoid injury to germination, apply fertilizer broadcast or in bands (pp. 110, 111).

In small plantings it is customary to plant lima bean seed with the eyes down, a practice which is unnecessary in favorable soils. Limas can be planted with some bean drills and with corn planters, by using special plates and brush cut-offs.

Cultivation during the blossoming period often results in failure to get a good set of beans. Deep cultivation should be avoided.

Varieties.—*Henderson Bush Lima,* of the *Sieva* or small-seeded type, is about 10 days earlier than the large-seeded kinds and is somewhat hardier but inferior in quality. It is very productive, is planted extensively for canning as Baby Limas and for the dry-bean crop but is not liked in most markets.

Fordhook, of the thick seeded or *Potato Lima* type, is planted most widely to produce green shell bush limas for market. The seeds are large, very plump, and high in quality. *Burpee Bush Lima* and *Burpee Improved* also are popular large-seeded kinds, all of which require about 75 days.

Pole limas are about two weeks later than the bush varieties and require a long frost-free season with warm nights. Yields generally are unsatisfactory in the North, with the exception of warmer localities. *Challenger,* of potato type, *Leviathan,* and *King of the Garden* are standard large-seeded varieties. The *Sieva, Carolina,* or *Small White,* known as butter beans in the South, represent the small-seeded class in a climbing variety. It yields heavily but the quality is low.

Harvesting.—Young, green shell limas are properly considered one of the most delicious vegetables. They must be picked before the pods begin to turn yellow, otherwise quality will be low and

market appearance unattractive. Quality is retained longer when the beans are sold in the pod, although many markets prefer that they be shelled and packed in pint or quart berry baskets. Limas grown commercially for canning, freezing, or the dry-bean crop are harvested and shelled by machinery.

Insects and diseases.—Insects and diseases generally may be controlled by the means described for common beans. The preventive practices of rotation, sanitation, and use of clean seed, however, may fail in case of attack by downy mildew.

Downy mildew of lima bean (caused by *Phytophthora phaseoli*) appears first as white, downy mold on the pods. In rainy

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Fig. 119.—Harvesting lima beans for freezing.

periods with warm days and cool nights, the organism may spread with great rapidity and destroy a planting within a few days. In areas where downy mildew is inclined to be prevalent, four or five applications of 4-4-50 bordeaux mixture or 20-80 copper lime dust at intervals of 7 to 10 days may be profitable as a standard, routine practice. Because the disease suddenly may develop to a serious stage it is unsafe to await its onset before beginning applications of the fungicide. Spacing rows and plants to assure free circulation of air and well-balanced fertilization to avoid excessively rank growth are important preventives.

MULTIFLORUS BEAN (*P. coccineus*)

This species is most familiar in the tall, climbing *Scarlet Runner* and *White Dutch Runner*, or *Butter Bean* varieties. It is characterized by the habit of the cotyledons remaining below ground in germination and by the large, ornamental flower clusters. The vines are very vigorous and productive and the crop responds to the culture suitable for common beans. The beans can be used in the snap, greenshell, and dry stages.

BROAD BEAN (*Vicia Faba*)

The broad bean is one of the most ancient of cultivated vegetables and was familiar to the Hebrews of the Old Testament. It is commonly grown in Europe and is popular with the Italians but general planting in this country is limited both by the small demand and by climatic circumstances. The name Horse bean arises from use of the crop as feed.

Broad beans thrive best under cool, moist growing conditions and do not succeed in hot, dry areas. Their requirements and culture are similar to garden peas, but the seeds should be spaced 3 to 5 inches in the row.

Where early summer may be hot and dry the seed can be sown under glass about two weeks before the usual time for outdoor planting. Transplanting to the garden then takes place when the young plants are a few inches tall, thus advancing the crop so that blossoming may occur before high temperatures and low humidity interfere with the set. The beans are used in both green and dry condition. *Broad Windsor* is the best known variety.

ASPARAGUS BEAN (*Dolichos sesquipedalis*)

Yard Long is the only variety commonly representing this species. The plants are climbing in habit and the slender pods, 1 to 2

feet long, are used in the snap stage. The variety is of little value except as a novelty.

The **Soy Bean** (*Glycine Max*) and the **Cow Pea** (*Vigna sinensis*) are valued by American vegetable growers mainly for green manurial purposes; however, meals and oils from soy beans are of great importance, the dried seeds of cow peas are familiar as "blackeyed peas," and the seeds of both occasionally are used as food in the green-shell stage.

XXI

POTATO AND SWEET POTATO

The potato, also called white or Irish potato, and the swe potato outrank all other vegetable crops in economic importanc In recent years the annual farm values of the two have averag approximately $200,000,000 and $50,000,000, respectively. The provide a most common and usually the cheapest sources of carb hydrate food, the potato leading in the North and the sweet potato i the South. They are dissimilar in botanical relationships and cu tural requirements. The edible portion of the potato is a thickene underground stem, or tuber, and that of the sweet potato is a thick ened or tuberous root.

POTATO (*Solanum tuberosum*)

History and importance.—The potato is native to South Am erica. It was introduced to Europe by the Spaniards in the sixteent century and Drake is supposed to have carried potatoes from th West Indies to Ireland in 1586. About a hundred years elapsed b fore the value of the potato as a food crop was appreciated generall Its cultivation proceeded most rapidly in Ireland and within a fe generations spread to all temperate parts of the world. In 171 Scotch-Irish immigrants to New Hampshire introduced the pota to the North American continent.

The world crop amounts to over six billion bushels annually, an that of the United States averages about three hundred and fif million bushels. The potato was the most important factor in cur ing the famines that formerly devastated Europe and today serv as the most important carbohydrate food crop of densely populat temperate lands.

Plant characteristics.—The potato is a herbaceous perennial the *Solanaceae* or nightshade family, but its culture is as an annu It is propagated by division of the tubers, short thickened unde ground stems with numerous eyes or buds. The potato usual blossoms profusely and occasionally produces seeds which yie varied progenies. The other solanaceous vegetable crops are di cussed in Chapter XV.

Climatic adaptations.—The potato is sensitive in its climat responses. It is injured by frost but requires cool growing cond tions and substantial rainfall to produce maximum yields. The o

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FIG. 120.—A well grown crop of certified seed potatoes.

timum temperature range is considered to be 60° to 75° F. Tuber formation in particular is affected adversely by high soil temperatures. Conditions in this country are most nearly ideal in Maine and in the higher, irrigated areas of the inter-mountain states of the West. Large and profitable yields, however, are produced in nearly every state by growing the best adapted varieties in the most favorable localities and seasons. Thus the potato succeeds as a winter crop in the extreme South and as spring and summer crops northward.

Soil requirements.—In this matter, E. L. Nixon * is quoted for his concise yet inclusive treatment of the subject.

"The best soil for economical potato production is one which contains an abundance of humus, provided it is well drained. Land that is not naturally well drained or will not respond to drainage is not adapted to economical potato yields. If what have been termed "heavy" soils are charged with sufficient humus they are transformed from the least desirable soil type for economical yields to the most dependable, especially in seasons of adversity. Part of the misconception, that heavy soils are not adapted to economical potato yields, is based on the knowledge acquired from soils depleted in humus. Of the two soil types, light and heavy, both depleted in humus, it goes without saying that the lighter soil is more desirable. For most economical yields, an abundance of humus is indispensable for both types."

It may be added that light, coastal plain and similar soils are employed most extensively in growing the early crop. Soils that are various degrees heavier support most of the vast acreage of late potatoes, with the notable exception of the medium to light, glacial drift soils typified in Aroostook County, Maine. Muck soils are used to an increasing extent. Very heavy, compact clays are undesirable. In general, light soils produce brighter-skinned potatoes.

Classification and varieties.—The commercially more important groups and varieties of potatoes are as follows:

1. *Cobbler*—the most widely planted early type, also grown for the late crop in cooler short-season regions of the North. Principal variety *Irish Cobbler.*

Other important early groups are *Early Ohio* and *Triumph* which find greatest popularity in the Midwest and South, respectively.

2. *Green Mountain*—especially adapted to typical New England and Long Island conditions. Principal varieties are *Green Mountain, Norcross, Gold Coin.*

3. *Rural*—the best adapted for heavier soils and drier regions, late in season. Principal russet varieties are *Dibble Russet, Rural Russet, Late Petoskey.* Principal smooth-skinned varieties are *Rural New Yorker No. 2, Carman No. 3, Sir Walter Raleigh, Number 9, Heavyweight.*

The *Burbank* group is important in the West.

* *The Principles of Potato Production,* by E. L. Nixon, published by the Orange Judd Publishing Company, Inc.

Chippewa, early, and *Katahdin,* midseason or late, are promising new varieties.

Rotations.—The best rotation for potatoes is one that will maintain the supply of soil organic matter at the highest practicable level. Details must be worked out in accordance with climate and the other crops that are required. Terry, Ohio's great pioneer potato grower, sagely observed, "After many changes I have settled on a three-year rotation of clover, potatoes, and wheat." He said a good and perfectly safe four-year rotation would be, "1. Clover manured for corn, 2. Corn for silo followed by rye, 3. Potatoes on rye sod, 4. Wheat seeded with clover and perhaps a little timothy."

Wheat followed by sweet clover (sown over the wheat in very early spring) the first year and potatoes the second year make a popular two-year rotation. Careful regulation of the acidity level is required to assure good stands of sweet clover without liming so heavily that scab will become troublesome. Alkalinity and high acidity both are unfavorable for potatoes, the range pH 5 to pH 6 or slightly lower being considered optimum.

Old sods generally produce lower yields than young sods and frequently are infested with grubs and worms that render much of the crop unmarketable. Avoid second year and older sods (p. 180).

Preparing the seed bed.—Nixon wrote: "The ideal seed bed for potatoes is one having a uniform distribution of organic matter, fine soil, stones (if any), clods, and air spaces throughout the entire plowed area. Such a seed bed cannot be made with ordinary farm tools if the organic matter is plowed to the bottom. A seed bed for potatoes should be worked from the bottom up and not packed from the top down. Terry was so convinced of the importance of a loose seed bed throughout that he said, "I wish I could do all other operations, after plowing, with a balloon."

Deep disking of heavy cover crops before planting is common in order to secure better distribution of the material.

Good seed.—Nearly all potato diseases may be seed-borne. Furthermore, inherent yielding capacity of disease-free lots of the same variety may vary greatly from different localities and even with the stocks of neighboring growers.

Certified seed produced from high-grade foundation stock and with expert inspection in field, during storage, and at bagging ordinarily assures the buyer good seed. Sources should be proved and chosen, however, by careful checking of the yields secured.

Because quality or its lack is hidden in the seed to a great extent, integrity of the seed grower or agency warrants careful consideration. The best seed, although more expensive, nearly always is a profitable investment in terms of increased yield. Relatively disease-free and vigorous seed is produced most readily rather far

North and at the higher altitudes southward. Well-grown, home-raised seed, only one generation removed from such sources, is planted extensively and with excellent results in the middle states.

Medium-sized, not overmature, dormant, and unshriveled seed is ideal. As large seed is cut to poor advantage, more bushels to the acre are required. Small potatoes, secured by relatively close planting, and No. 2 sizes from good certified stock, are growing in popularity.

Seed potatoes that have been kept in warm storage lack vigor. Proper temperatures are discussed later under *Storing*.

Disinfecting seed.—Chemical treatment for seed-borne diseases may be advisable under certain circumstances. Procedure is described later (p. 416). Disinfection after active sprouting begins may cause serious reduction in germination.

On the subject of seed treatment Nixon says: "The more I follow up good potato growing, the more I am tempted to question the efficacy of seed treatment. With seed badly infected with scab or rhizoctonia it sometimes appears profitable to treat with some chemical. Such potatoes, however, do not come under the category of good seed. Neither can the producer of such potatoes be classified as a good grower. Good seed and good cultural practices, together with varietal adaptation, reduce tuber-borne diseases to a point where it becomes questionable if chemical treatment of the tubers adds to the profits."

Greensprouting prior to planting is practiced widely in Europe and to an increasing although very limited extent here. Findings of Hardenburg * indicate: "Greensprouting promotes earliness of emergence and more rapid early growth of both foliage and tubers. This advantage in top growth may not be maintained in standard late-crop varieties allowed to reach maturity." He found generally fewer stems to the plant, increases in stolon number and stolon weight and in number of tubers to the stem. Quoting again: "The yield per acre of marketable size tubers is significantly increased by the greenspouting treatment. This is owing to the cumulative effect of earlier plant development, resulting in the setting of tubers under the most favorable conditions of temperature and soil moisture, and of an increased tuber-set. Lengthening the period of greening beyond two weeks did not result in sufficient increase in yield to justify the extra risk and expense involved in greening longer."

Greenspouting may be accomplished by spreading the seed on a barn or shed floor, or on shallow trays fitted with corner pegs or high ends to permit stacking without excluding light. Dry sand sometimes is used barely to cover the tubers which then are watered occasionally to prevent wilting. The tubers should be placed in flats

* *Cornell Bulletin* 632.

with the bud ends up. Cool greenhouses provide ideal conditions for greensprouting seed potatoes.

Mechanical planting of greensprouted seed is possible if completed while the sprouts remain short and sturdy.

Warming very dormant seed, by storing for a short time at moderate temperatures, will start the buds into activity and often secure earlier and more uniform emergence, particularly with very early plantings.

Cutting seed.—It is generally conceded that the ideal seed piece is blocky in form and 1¼ to 1½ ounces in weight, also that stock from which these sizes can be made with the least cutting gives greatest economy in amount of seed and most assurance of a full stand.

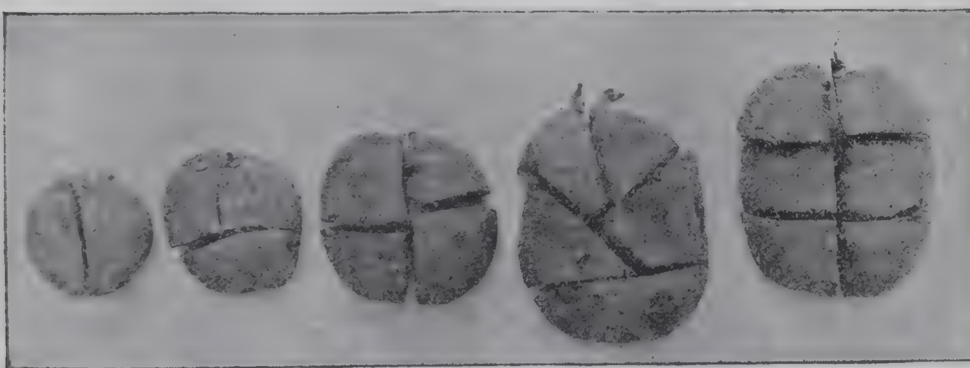


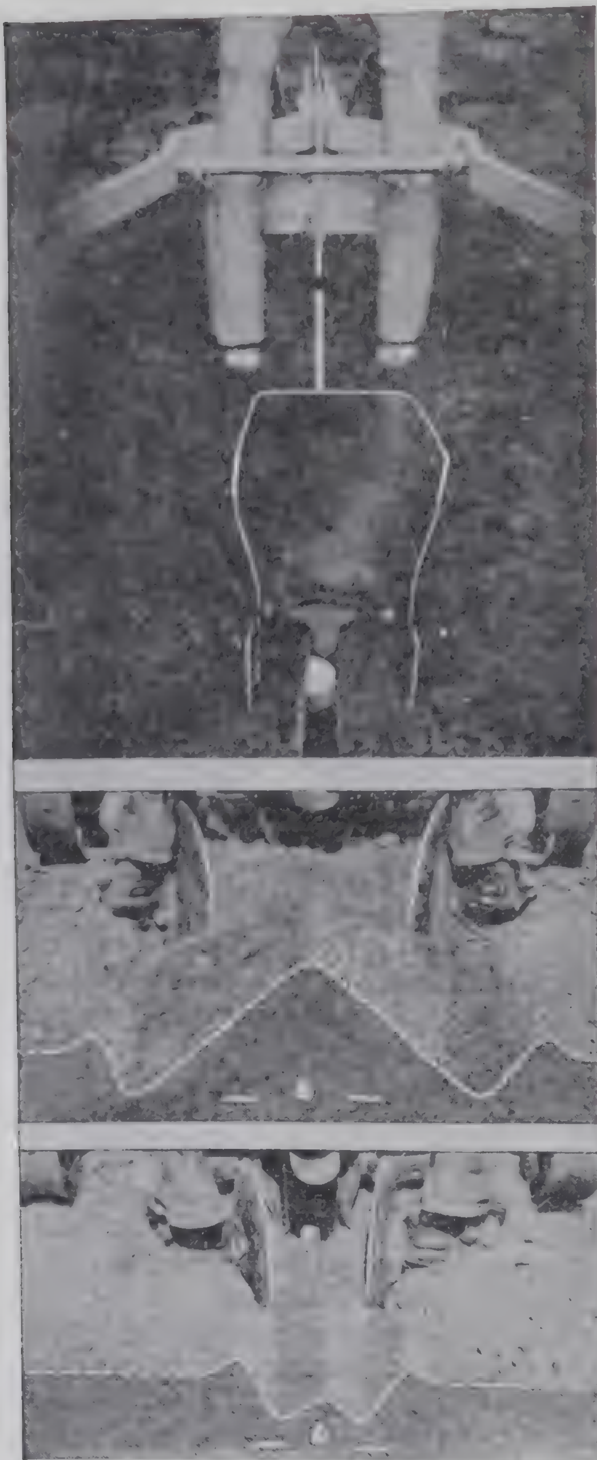
Fig. 121.—Typical lines of division in cutting potato seed of different sizes.

Favorable lines of division in cutting tubers of different weights are illustrated. When cut in the manner and size indicated it is generally not necessary to look for eyes. Tubers less than two ounces in weight generally should be planted whole.

After cutting, the seed must be protected from the sun and from drying winds. Exposure of even one hour in the sun may cause serious reduction in yields. It is safest to plant promptly. If perchance cut seed must be kept for a time, it is best to store in a moderately warm, humid place to encourage healing or "corking" of the cut surfaces. Spread enough to avoid heating.

Fertilizing.—No general recommendation can be made concerning the kind and amount of fertilizer likely to prove most profitable with potatoes.

Representative practices, on an acre basis, are about as follows: for the early crop, on light soils 1000 to 2000 pounds of 4-8-8, or the equivalent in a ratio of approximately 1-2-2 or 1-2-2.5; for main-crop potatoes, on the heavier soils, 600 to 1000 pounds of 5-10-5, 4-10-6, 4-12-4 or 3-12-6, or, in some cases, superphosphate



A. B. Farquhar Co., Ltd.

FIG. 122.—Band placement of fertilizer with deep and shallow covering in potato planting.

with much manure and legumes; for areas deficient in potash 4-8-12 and 3-9-18.

Insufficient potash under some conditions results in soggy quality when cooked, whereas ample potash produces a desirable mealy condition.

Manure at the rate of 10 or 15 tons to the acre is applied during the fall and winter by the majority of growers, but many prefer to apply it as early as possible on the sod.

Manure is by no means essential when legumes are used skilfully. In fact, there are definite possibilities with strong growing non-legumes (pp. 80-91).

As a rule, the most efficient placement of the fertilizer is in bands on both sides of the seed and at the same or slightly lower level. Placement with the seed, or directly above or beneath it, is very likely to cause serious injury to sprouting (p. 111).

Planting.—The early crop and the late crop in northern or high altitude areas generally are planted as soon as the soil can be prepared properly.

In slightly warmer regions early planting, with the aid of high fertility, sufficient moisture, and good foliage protection, is likely to secure the heaviest yield by providing maximum length of growing season. In warm localities, however, where dry midsummer weather may check growth, much second growth with many misshaped tubers is often the result of early planting. Under such conditions the most profitable planting time may be late in May or June, but too long delay is certain to yield light, immature crops.

Planting depth of 3 to 4 inches, as checked by leveling the soil after the planter has passed over it, is proper for most conditions. On heavy soils, deep planting but shallow covering (one inch) is conducive to quick sprouting and early emergence, but deeper covering is likely to be better in dry seasons and on light soils.

Popular spacings in the row are 10 or 12 inches for cut seed and about 15 inches for small, whole seed. Between the rows 30 or 32 to 36 inches are the distances commonly allowed, 30 being correct for truck-mounted sprayers. Such spacings, with seed pieces weighing about 1¼ to 1½ ounces, will require about 18 to 25 bushels to the acre, which is the amount of seed commonly used by most successful growers.

Cultivation should be managed for the primary purpose of economical and effective weed control. A standard program is to harrow one or more times before many of the young plants appear; cultivate as soon as the rows can be seen, working more and more shallowly and farther away as the plants develop; use the weeder frequently, both with and across the rows at first, then only with the rows and always in the same direction when the plants begin to fall

over. Slight hilling in broad, low ridges may be advantageous to smother late-starting weeds and protect the tubers from the sun. High, narrow ridging, or late, deep, and close cultivation for any other reason, however, is nearly certain to cause sufficient root injury and loss of moisture to curtail yields seriously.

Foliage protection of the highest order is essential for maximum yields under most conditions. For this purpose no material has been found superior on the potato crop to properly made 4-4-50 bordeaux mixture. Copper lime dust is very satisfactory when well applied. Arsenicals can be included with either. Details of preparation and application have been discussed (pp. 168-176).

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FIG. 123.—Potatoes at the tuber-making stage. Maximum yields depend upon continuing effective protection of the foliage.

For protection from flea beetles the first application usually should be made as soon as enough young plants appear to indicate the rows. Subsequent applications must follow at intervals of about 7 to 10 days, varying in accordance with rates of foliage development or especial threats of injury.

Irrigation.—Even in humid regions, rainfall very often is insufficient or too poorly distributed for full yields of potatoes. The early crop in particular may be cut short and even killed by only a few days of hot, dry weather during the later stages of growth. Commercial vegetable growers, who often grow potatoes in rotation with market garden or truck crops, sometimes produce the crop under irrigation with remarkably high yields. The potato crop requires enormous amounts of water and, under otherwise favorable

conditions, is very responsive to irrigation. Many growers in situations favorable for inexpensive furrow irrigation are finding artificial watering profitable.

Any sort of irrigation is very expensive and the main dependence of large and small-scale potato production must continue to be on increasing the depth and organic material of the soil to a degree that will overcome the most severe effects of droughts.

Harvesting.—Digging the early crop may begin as soon as the tubers attain acceptable size, provided prices and yield at the time warrant the very considerable sacrifice in tonnage incidental to harvesting even a week or two before full development is reached. Digging the late crop should be delayed until the tubers have reached sufficient maturity to avoid undue chafing or peeling of the skins, but it ought to be completed before there is danger of hard freezes, which cause extensive losses somewhere nearly every season.

Elevator-type diggers are in general use and improved models are being introduced which reduce the amount of cutting and bruising. Such damage may be minimized by running the digger deep enough to move a considerable quantity of earth most of the way over the machine with the potatoes.

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FIG. 124.—Potato digger especially designed to prevent damage to the tubers, a common cause of serious reduction in the grade.

In picking, the workers must be supervised so that there will be no unnecessary throwing about or other roughness in handling the tubers.

For similar reasons potatoes picked into crates or barrels will suffer less injury in transit to storage than those handled in bags or in bulk from wagon boxes. Great care to reduce injury at harvest is fully justified by reduction of storage losses and a better market grade.

Although the average yield of potatoes for the United States is a little more than 100 bushels an acre, the best growers regularly expect 250, and some of the more skilful and favorably situated attain 400 to 500 bushels with great consistency.

Grading and packing.—Comparatively inexpensive sizing machines are used to separate one or more sizes of first-grade tubers and the second grades from the tiny potatoes and the dirt. Blemished, spoiled, and misshaped specimens are removed by hand picking as the tubers pass over the grading belt. Latest official specifications of grades can be procured from the United States Department of Agriculture, and usually from the county agricultural extension representatives.

Mathews Conveyor Co.

FIG. 125.—Field grading and bagging often are expedient. Sometimes the machine is mounted on a low sled to be moved conveniently as the work proceeds.

Cleaning potatoes before they are packed for shipment has become a regular procedure in several areas. The fact that clean potatoes are sold more promptly and that better prices are secured indicates general spread of the practice. Under some conditions brushing machines do a satisfactory job. With heavier soils and muck, washing is more efficient and must include some means of drying, except in arid regions.

Burlap bags containing 100 pounds are the package used most extensively. Consumer-size packages, such as 10- or 15-pound, cotton, special mesh or strong paper bags, are employed to some extent, particularly for marketing fancy grades.

Marketing proceeds through all the customary channels of the produce trade. Whether it is better to sell directly from the field or to store for later sale may depend upon market opportunities, storage quality of the crop, and facilities available. In general, value rises very little and sometimes falls during the winter and early spring immediately following very large and difficult-to-sell fall crops, and advances most following small, readily salable crops.

Storing.—The pit method described earlier (p. 207) is best for the grower with a warm house cellar and without special storage facilities. Unheated cellars of houses or barns, however, often are very satisfactory, especially when altered as may be required for frost-proofing, ventilation, and complete exclusion of light.

Well designed and constructed, properly managed bank storage cellars (p. 209) provide nearly ideal conditions for keeping potatoes. The grower who contemplates investing in an expensive structure of this nature, however, should first consult special bulletins on the subject and inspect successful storages, even at some expense for travel.

Shrinkage and other storage losses are least within a temperature range of 36° to 40° F. Temperatures above 40° F., especially during the latter part of the storage period, lead to early sprouting. Temperatures close to freezing, if prolonged, are conducive to conversion of starch to sugar, with development of an objectionable, sweet flavor.

Humidity of about 90 per cent is most suitable. Somewhat higher temperatures and humidity during the first two or three weeks of storage, however, favor rapid healing of cuts and abrasions.

Unless the crop is stored in crates, raised, slatted floors and slatted division walls must be constructed to permit aeration of the pile. Otherwise blackheart may develop from lack of air and the high temperature in the center of the pile. More ventilation will be required toward spring after sprouting begins. Good storage is

doubly important to preserve seed potatoes in sound, firm condition until planting time.

Refrigerated cold storage is useful in warmer regions to hold potatoes dormant from March until midsummer for planting at that season to produce seed stock.

Producing seed potatoes.—Scientific development of improved strains or foundation stock is a specialized undertaking. For the purposes of most growers it will suffice to start with the finest stock obtainable, treat the seed, give the best culture, rogue plants affected with virus diseases in the field, and store properly.

Diseases of the potato, which make a long list, ordinarily cause the grower more concern and greater loss than insects. The importance of using clean seed and giving adequate protection to foliage already has been emphasized.

Late blight (caused by *Phytophthora infestans*) usually becomes active late in the season, particularly during wet weather, and generally is the most serious of potato diseases. A white mildew appears on the lower surfaces of the leaves, which soon turn brown and die. The disease attacks stems and tubers also, over-wintering in the latter, often resulting in serious losses in storage. Crop rotation, the use of clean seed and thorough, timely spraying with bordeaux mixture or dusting with copper fungicides will accomplish control. Applications should begin as soon as the rows can be seen and follow at intervals of a week or ten days to completely protect foliage and stems.

Early blight (caused by *Alternaria solani*) appears as brown leaf spots marked by faint concentric circles and may cause shallow sunken decayed areas on the tubers. The fungus survives in the soil and on potato-vine trash. Rotation and application of bordeaux mixture or a copper dust are the means of control.

Rhizoctonia (caused by *Corticium vagum*) is widely prevalent, appears on the tubers as dark, soil-like specks, and, when introduced with the seed piece, may create great havoc by girdling the stems below the ground. If diseased seed must be used it should be disinfected while dormant and before cutting by soaking for 1½ hours in a solution of 4 ounces of corrosive sublimate in 30 gallons of water, or the Semesan Bel instantaneous dip may be used according to the manufacturer's directions. Crop rotation is advisable.

Scab diseases attack the tubers and cause irregular, russeted or darker areas which may involve nearly the entire surface. Marketability is seriously impaired by only a small amount of scab. Lime or other alkaline materials should not be applied in greater amount than is necessary to accommodate the other crops in the rotation

and then as far ahead of the potato crop as possible. A reaction of pH 5.4 or lower will inhibit the development of scab. Acid-forming materials, such as sulphate of ammania, in the fertilizer mixture help to control scab.

Blackleg (caused by *Bacillus phytophthorus*) is so-called because of the characteristic blackening of the stem with attendant stunting, yellowing, and eventual killing of the plant. Its prevalence is greatest in cool weather and cooler regions. The use of disease-free seed and prompt removal of diseased plants in the field are recommended control measures.

Wilt (caused by *Fusarium sp.*) affects the vascular system of the plant, which may wilt, turn yellow, and die. In the tuber it is an important cause of discoloration at the stem end. In cutting seed, all such specimens should be discarded. Preventive measures are a long rotation, an abundance of organic matter in the soil, and the use of disease-free seed.

Virus diseases, as **leaf roll, mosaic, yellow dwarf,** and **spindle tuber,** overwinter in the tubers and are disseminated in the field by insects or mechanical carriers of the juices of affected plants. Control is obtained with seed from expertly and thoroughly rogued seed-fields.

Insects.—The principal insects attacking potato foliage are the Colorado potato beetle, flea beetles, and leaf hoppers. Injury by leaf hoppers is the common cause of tipburn. For insect control it usually is necessary to include arsenicals, preferably calcium arsenate with the fungicide. Presence of aphids may demand the application of nicotine. White grubs, wire worms and millipedes often cause serious damage to the tubers. Refer to Chapter X discussion of insect control.

SWEET POTATO *(Ipomoea Batatas)*

History and importance.—The sweet potato, generally considered a native of tropical America, was distributed widely by early Spanish and Portuguese navigators. Today it ranks as a very important or leading food crop in many tropical and subtropical lands. In the United States the sweet potato is grown extensively throughout the southeastern and south central regions. Vast quantities are shipped to northern markets.

Botanical relationships.—The sweet potato belongs to the morning-glory family or *Convolvulaceae*. The specific name "potato" originated with the Indian name *batatas*, which later was applied also to the white or Irish potato.

The plant is a tuberous-rooted perennial, although it is cultivated as an annual. In the northern part of its range, flowering is

uncommon and seed seldom is produced even under tropical conditions. The trailing vines strike root at the joints. Leaves are more or less heart-shaped or halberd-shaped, with and without lobing. Tubers of different varieties vary greatly in form, size, and color of skin. The flesh varies in color, texture, moisture, and quality.

The term "yam," as used by the produce trade, applies to moist-fleshed sweet potatoes.

Climatic requirements.—The plant is very susceptible to cold; it demands warm temperatures, day and night, and an abundance of sunshine. For satisfactory results there should be a growing season of at least 4 months without frosts and with warm nights.

Although the sweet potato is more tolerant of dry weather than most vegetables, it thrives best with moderate rainfall. Heavy rainfall or irrigation after the vines cover the ground may cause excessive vine growth at the expense of tuber development, and interfere with proper maturing.

The sweet potato is often grown in northern gardens, but it is futile to undertake its cultivation commercially where climatic conditions are unsuitable. The southern half of New Jersey is the most northern area of very large production; the crop is of local commercial importance in southeastern Pennsylvania and in parts of Ohio, Indiana, Illinois, and Iowa.

Soils.—Light soils invariably are regarded as the best for sweet potatoes. A moderate proportion of sand in the top soil, with a fairly retentive subsoil, provides ideal conditions. Whatever the soil type, it should be warm, loose, and well drained. New land is regarded as especially valuable but should first be planted one year to corn or another crop. Some of the driest and most sandy soils give good yields of fine tubers when well fertilized and if seasonal conditions are favorable. Sweet potatoes may pay on land that is too poor for cotton or tobacco, although highest yields cannot be expected in impoverished soils.

Varieties.—In selecting a variety for local sale or for shipment, market preferences and climatic and soil adaptations should be considered.

Varieties of the *Jersey group*, which are best suited to conditions in the northern range of production, bake to a dry, mealy texture. Important representative varieties are *Big-Stem Jersey*, *Yellow Jersey*, and *Gold Skin*.

Varieties of the moist-fleshed types, such as *Nancy Hall* and *Porto Rico*, are most popular and widely planted in the South. *Dooley*, *Southern Queen*, and *Pumpkin "Yam"* also are well known.

Propagation.—Sweet potatoes are propagated by slips produced from roots bedded in warm, moist sand or soil, and, in the warmer zones, vine cuttings from the first planting often are used to extend

the acreage. In the extreme South small tubers or pieces occasionally are planted like white potatoes and then cuttings are used for further increase.

Selecting seed.—The tubers for propagation of plants for the next year's crop should be selected in the field at harvest time, when the performance of individual hills may be observed in respect to vigor, productiveness, freedom from disease, size, shape, and uniformity of tubers. Split the stem from each hill and save seed only from plants of which the insides of the stems are not streaked with black, and also reject all tubers that appear to be diseased. Medium to small but well-matured tubers usually are saved because a bushel will produce a greater number of plants than the larger tubers. Cut or bruised specimens should be rejected. Best results are secured when seed stock is picked into suitable containers and stored without further handling until bedding time. Sorting during storage to remove decayed roots generally increases rather than diminishes loss by rotting.

Disinfecting seed.—Before the roots are treated they should be sorted to discard all that show decay or severe shriveling. A solution of corrosive sublimate (mercuric chloride) in the proportion of 4 ounces in 30 gallons of water is prepared in wooden containers of convenient size. The seed, in bags, crates or baskets, is immersed for 8 to 10 minutes, then rinsed with fresh water and spread out to dry before bedding. After treating 10 bushels of seed add ½ ounce of corrosive sublimate dissolved in hot water and enough water to bring the solution to its original volume. The solution becomes weaker with use and must be discarded and replaced after three treatments. If preferred a suitable organic mercury dip such as Semesan Bel may be used according to the manufacturer's directions.

Amount of seed.—Ordinarily about three bushels of seed are required to produce enough plants to set an acre. Because several factors may influence the yield of plants, however, many growers bed a bushel of seed for each 1,000 plants required, although two to four times this number may be produced.

Where climate permits the use of cuttings, enough seed is bedded to plant only about one-eighth of the proposed area.

Plant beds.—In the North, sweet potato plants must be started in hotbeds with glass or other covering and with artificial heat. In the far South it usually is unnecessary to provide any protection for the plant bed. Under intermediate conditions, glass or muslin-covered cold frames are suitable.

Good plants can be produced in any type of hotbed. Hot water or steam-heated and flue-heated hotbeds, however, are considered especially satisfactory in New Jersey, the most northern large-scale sweet potato growing area. The waterproof canvas or muslin cover is

kept over the beds during the early stages and in cold weather but is rolled back later whenever weather permits.

Ordinary manure hotbeds often are used. The depth of manure required depends upon the locality but one foot usually is sufficient.

Details of construction and general management of hotbeds and coldframes, and general considerations in plant growing, are described in Chapter IV.

The outdoor plant beds as used in the South are excavated about 6 inches deep and 6 feet wide in a level, well-drained place on the sunny side of a building, tight fence, or other windbreak. Any convenient mulching material may be used to prevent rapid drying. It can be removed on warm days and put back at night to retain heat or to protect the plants from late frost.

Bedding the seed.—Bedding takes place about a month to six weeks before the time for transplanting in the field; 25 or 30 square feet of bedding space will be required for each bushel of seed, or about 8 to 10 square feet for one thousand plants.

Clean sand is best, but any fine, sandy soil may be used as the material for bedding. The sand in the beds, however, must be removed and replaced yearly with new disease-free material, preferably from woodlands, or it must be disinfected; the plant bed otherwise may become a most dangerous source of disease. Except for small areas, disinfection (p. 44) is probably cheaper.

In preparing the hotbed, sand is placed to a depth of about 3 or 4 inches or more—as much as 10 inches to secure uniform temperatures—in pipe or flue-heated structures. The surface is leveled evenly and is often covered with salt hay or other litter to hold the heat.

When the soil temperature, as indicated by a thermometer thrust into the soil, has dropped below 85° F., seed may be placed in the manure-heated hotbed. In artificially heated beds nearly constant soil temperature of about 70° F. generally is recommended.

On a mild day coverings are removed and the seed is placed, by hand, on the surface of the bed, usually with about an inch between tubers. Very large potatoes may be split lengthwise and the cut surface placed next to the sand. After tubers are placed, they are covered with about 3 inches of sand and then watered thoroughly, preferably with warm water.

Managing the plant bed.—Good plants cannot be grown without close, daily, sometimes almost hourly attention. Careful ventilation is necessary to regulate humidity as well as temperature. Chilling the plants invites disease, and too much heat produces rapid growth but soft plants. The air temperature in the frame never should fall below 60°, and higher temperatures up to 80° are preferred for some time after the tubers have been bedded. Water-

ing must be regulated as changing weather conditions demand. Flue or steam-heated frames require more frequent and abundant watering than do manure-heated and nonheated beds. As planting time approaches, water is applied more sparingly and high temperatures are avoided in order to prepare the plants for field conditions.

Pulling the plants.—Sweet potato slips are in ideal stage for transplanting when they have become well rooted and stocky and average about 8 inches in length after pulling. All the slips will not be ready at one time, however, and only those which are well developed are removed. While drawing a plant with one hand the parent tuber should be held in place with the other hand. Immediately after the plants are pulled the roots may be dipped in a solution of 1 pound of suitable organic mercury in 10 gallons of water.

FIG. 126.—Sweet potato slips or sets.

Harmful drying may occur during the interval between pulling the slips and setting them in the field. This should be prevented by having burlap, moss, or some other moist absorbent, in the bottom of the baskets or other containers and by covering the top with any convenient material.

Use of cuttings.—As indicated, vine cuttings from a relatively small, early planting provide the most economical means of propagation wherever the warm season is of sufficient length.

Even near the northern limits of sweet potato production, cuttings sometimes are used in producing seed stock. With care in planting and the use of clean land, the crop from cuttings is likely to be more nearly free from disease.

Cuttings are taken as soon as the plants begin to vine
They usually are made about 10 or 12 inches long and are pla
horizontally or obliquely with only an inch or two of the top
jecting above ground.

Rotation.—Sweet potatoes ordinarily should not be grown
rotation shorter than 3 or 4 years. Some truck farmers who
diseases and insects well in check, however, consider it advantag
to grow sweet potatoes two years in succession at the point
rotation where the supply of organic matter is lowest. Then
truck crops or farm crops are grown for at least four years. W
climatic conditions permit, intensive growers often harvest an
crop of spinach, lettuce, peas, beans, beets, cabbage, or some
vegetable before planting sweet potatoes.

Manures.—It is generally considered that maximum yield
be secured only when stable manure or green manures, usually
latter for reasons of economy, are given proper place in the rota
That place, however, is not immediately preceding the sweet p
crop. The best practice is to manure the preceding crops be
bright, smooth roots are not likely to be produced in soil conta
quantities of fresh organic matter. If sweet potatoes must foll
green manure, the ground should be thoroughly disked and pl
a month or more before the plants are set; better distribution
more rapid decomposition thus will be assured. Stable man
should be applied not later than during the preceding fall.

Lime, like manure, usually can be applied to better advan
before some other crop in the rotation. The sweet potato pla
quite tolerant of acidity and much liming is conducive to the d
opment of scurf. Nevertheless, if the area designated for this
happens to be very acid, testing below pH 5.0, yields are al
certain to be increased by thoroughly harrowing in one-half t
slightly more to the acre of pulverized limestone or its equivale

Fertilizing.—For northern commercial sections, where vari
of the Jersey group are grown as a truck crop and the short gro
season makes quick maturity necessary, mixtures containing 2
per cent of nitrogen, 4 to 8 per cent of phosphoric acid, and 10
per cent of potash are used effectively. The lower percenta
nitrogen, or perhaps none, may be advisable on highly fertile
ing soils or after heavy leguminous crops or manure. Applica
of 800 to 1000 pounds to the acre are most common northw
whereas half these amounts and a low ratio of nitrogen prove
cient with the different varietal requirements and climate
South.

Because sweet potato slips are very susceptible to injur
freshly applied fertilizer, the manner of application demands ca
consideration (pp. 110-111).

safe and very popular procedure is to apply the fertilizer a or two before planting. Properly spaced band-applications considerable possibilities where transplanting machines are . Side-dressing a week or two after planting, either with a spe-row distributor or with an attachment for the riding cultivator, standard and proved safe practice in many sections.

Soil preparation.—Because sweet potato slips must be trans-ted into the field at a season when the weather often is hot and it is important to plow as far in advance of planting as circum-ces permit. An ample supply of moisture usually can be con-ed thus and there is an interval during which weeds and latent grasses can be killed by occasional harrowing.

Level culture and ridges.—Ridging is a more general practice sweet potatoes than with any other vegetable crop. Some of advantages are better drainage, earlier warming of the soil, less ing of soil by wind, prevention of blown sand from covering young plants, provision of greater depth of soil close to the ts and easier digging. Cross-cultivation, however, may be prac-l on weed infested soils where level culture is practical.

A common means of making ridges is to back two furrows ther. Various special hillers also are employed, often with the izer first placed ahead in an open furrow. Many potato planters be adjusted to place the fertilizer and make the ridge at one ation (p. 410).

Planting.—Field planting should not begin until the soil is thor-ly warm and there is no further danger of frost. The most rable times are just before rains and as soon thereafter as the can be worked. If the ground is dry, puddling (p. 113) will t the roots in contacting soil moisture. With transplanting ma-s, watering nearly always should be included in the operation. with extensive hand-planting in very dry times it is by no an impossible task to apply a small dipper of water to each r (p. 112). It may be the means of securing a full stand and the , vigorous start that is fundamental to maximum yields.

Spacings with level culture and cross cultivation range from 24 30 inches each way. When planted on ridges, or on the level for ivation in only one direction, about 8,000 to 12,000 plants are n the acre; distances usually range between 12 and 24 inches in rows and 30 to 48 inches between the rows depending on the ing vigor of the variety and the fertility of the soil.

On small areas, the slips are often set by hand, with the aid of ers or trowels, or in small furrows. Machine planting is exten-on large operations and deserves consideration because of the ibility of applying water automatically with each plant; the cost or may not be lower than with expert planters using tongs.

Sweet potato tongs are light wooden implements, usually home-made, with a spring to open the jaws. A slip can be grasped by the root and thrust into the soil by the operator almost without bending. The slips may be carried by the operator in a container suspended from the waist from which they are inserted directly into the tool or they may be dropped ahead by the same worker or by a helper. Under some conditions a so-called "shovel," a lath sharpened to a flat point, is used in one hand to open holes into which the slips are set by means of the tongs in the other hand. The soil is then pressed to the roots with the foot.

Vine cuttings often are planted by dropping them ahead of a worker who simply pushes the cuttings into the soil by pressing at the middle with a cane-shaped stick having a V-notch padded with cloth or leather.

Cultivation should be started soon after planting. The loose soil in the alleys is gradually worked toward the rows. Later, vine lifters are helpful. Riding cultivators often are equipped with weeder attachments which turn the plants in the direction of the row and stir the soil between plants. When the weeder is used each row must be cultivated in the same direction. By this means the amount of hand hoeing and the cost can be reduced greatly.

When the vines begin to interfere they sometimes are turned first to one side of the row and then to the other to permit one or two additional cultivations. Another plan is to turn the vines from two rows into one middle row and continue cultivation for a time in the alternate middles. A hoe handle, stick, or wooden rake is convenient for turning the vines. After the vines begin to cover the ground completely no further tillage is required, but it may be profitable to do a limited amount of hand weeding.

Two-horse riding cultivators, sometimes with discs for hilling, are most generally used until the vines become too large. Thereafter one-horse cultivators, sweeps, and plows of various designs are employed.

Pruning the tips of the vines, although sometimes practiced, generally reduces yield.

Harvesting.—Sweet potatoes are palatable as soon as they have attained large enough size to be worth cooking, but the yield is always greatly sacrificed if they are dug too early. High prices may make up for the reduced yield. The crop for storage should be well matured, but in any event it should be harvested before hard frosts. If frost occurs harvesting must be done immediately, before decay passes down the vines to the tubers. It is important also for the ground to be dry and the weather bright and sunny to favor the rapid drying of the tubers, which never should be left on the ground during the night. The usual plan is to allow them to dry in the field

for an hour or two and then haul them to temporary or permanent storage. It is most convenient to use specially equipped plows with vine cutters.

Utmost care in digging and at every point in picking and handling is required to minimize bruising and scratching the tubers. The smallest injuries detract from appearance and cause increased losses in storage. After digging, the tubers should be carefully pulled from the plants and gently placed by hand in baskets or crates. Sacks are unsuitable because extensive bruising occurs when they are used and the tubers soon become dark and unattractive.

Average yields in most states do not exceed 100 bushels to the acre, but yields two or more times that large are common among skilful growers.

Grading and marketing.—In selling directly from the field nearly all growers grade the crop as it is picked, thus avoiding the damage incidental to extra handling. In fact field-grading of the crop that is to be stored generally is practiced in order to reduce the amount of handling required when taking it out of the storage. Federal specifications of grades are available.

Bushel-size hampers, baskets, and crates are the most popular packages. In winter it may be necessary to line these containers with paper as protection from cold. When temperatures are very low, special precautions are required to prevent chilling or freezing. Insulated trucks and railroad cars must be used, sometimes with the added protection of heaters or stoves.

Storage.—Tubers for storage should be free from disease, cuts, bruises, or frost injury and they must be handled with great care.

Relatively high temperature and dry atmosphere are the requisites for successful storage of sweet potatoes, which in the South sometimes are kept in pits or outdoor cellars. As a rule such storage is undesirable because conditions cannot be thoroughly controlled. For small quantities, storage in a warm loft or in a cellar near the furnace is satisfactory.

For commercial storage, specially constructed or remodeled buildings are recommended. The structure should be well insulated to prevent condensation of moisture on the walls and to maintain even temperatures. Thorough ventilation must be possible. If bins are used they should be narrow, not over 6 feet deep, have raised slatted floors and double, slatted divisions, and air spaces between the bins and the outside walls. A concrete subfloor and screened openings may be required to keep out rats and mice.

In small structures heat can be furnished by a stove set up with a long run of horizontal pipe. The most satisfactory heating system, however, is a hotwater boiler with coils of pipes running around the outside walls and beneath the slatted floors. Sometimes the

boiler may be placed and equipped with valves so that it can serv to heat the plant bed in the spring and the storage in the fall an winter.

The temperature should be about 85° F. when the potatoes a put in and should be held close to that point for 10 or 15 day until after the sweating or curing stage, which is a drying proces mainly. During this period the fire must not be allowed to die n should proper temperatures be maintained by too much restrictic of ventilation. With proper curing many cuts heal and the hig moisture content of the tubers is reduced.

Thereafter a temperature of about 50° F. should be maintain and ventilation can be managed mostly through the warmer hou of bright days.

During the storage period sweet potatoes should not be move or otherwise handled.

Sweet potato houses should be disinfected before the crop stored. The instructions that follow are from Farmers' Bullet 1442, Storage of Sweet Potatoes.

"Spray the entire interior of the house with a solution of copper sulpha (bluestone), made in the proportions of 2 pounds of copper sulphate to 50 g lons of water. All bins or other containers previously used should be treat also.

"Apply, thoroughly, a coat of ordinary whitewash to the entire interior.

"The most effective method is to fumigate the house with formaldehyde g Formaldehyde is an irritating and poisonous substance, and must not be breath nor allowed to get into the eyes. It is thus necessary to get out of the hou quickly after the gas is released. Where formaldehyde is to be used, the follo ing directions should be noted:

"Each 1,000 cubic feet of space to be fumigated requires 3 pints of comm cial formalin (a 40-per cent solution of formaldehyde in water) and 23 ounc of potassium permanganate. The potassium permanganate should be placed in deep container such as a 1- or 2-gallon stone jar and the required amount formalin poured upon it. A sufficiently large container for the formalin shou be used, so that the required amount can be poured into the jar without t necessity of measuring successive portions. Speed in handling is essential safety. If a large house is to be fumigated, several receptacles should be us distributing them uniformly over the house. If several are used, the requi amount of permanganate should be measured into each beforehand and the j properly distributed over the house. All doors and windows should be tigh closed except one convenient door. The formalin should be first poured into container farthest from the open door, and the operator should work rapi toward it, getting out of the house promptly. The house should be kept tigh closed for at least 24 hours."

Insects.—The sweet potato has fewer insect enemies than ha many other vegetables. Cutworms and grubs are troublesome som times, especially in sod lands (pp. 178, 180).

The sweet potato weevil, destructive to the roots of the plan is combated by rotation, the use of clean seed and plants, a thorough clean-up and burning of refuse after harvest. Ars

cals applied to the slips before planting and in good time on the ines in the field will eliminate many beetles before egg-laying ccurs.

The sweet potato gold bug, tortoise beetle, or peddler may se-erely attack the young plants. The general recommendation is a pray of 2½ pounds of lead arsenate in 50 gallons of water or a lust of one pound of the arsenical with about 6 pounds of hydrated ime or wheat flour.

Diseases of the sweet potato cause enormous losses both in the ield and in storage unless appropriate preventive measures are ex-rcised. When these are executed with thoroughness, losses from lisease generally can be reduced to a very low level. It is notable hat leaf diseases are unimportant, as a rule, and fungicides are neffective against the serious root and stem diseases because the ausal organisms invade the interior.

The preventive program, practices of which already have been described with the operations of growing and handling the crop, consists of seed selection, use of clean soil in the plant bed, disin-fection of seed potatoes before bedding, crop rotation, careful han-dling, disinfection of the storage equipment, and proper regulation of storage conditions. Further discussion is unnecessary except briefly to classify and describe the diseases. The material that fol-lows has been arranged from Farmers' Bulletin No. 1059 which describes and illustrates the important sweet potato diseases and prescribes measures for their control.

CLASSIFICATION AND DESCRIPTION OF SWEET-POTATO DISEASES

Field diseases:

Stem rot (wilt). Discoloration of the young leaves and bundles of the stem; wilting of the vines. Caused by *Fusarium batatatis* and *F. hyperoxysporium.*

Black rot. Black spots and cankers on the sprouts and circular black spots on the roots. Caused by *Ceratostomella fimbriata.*

Foot rot. Rotting of the stem near the soil, followed by wilting of the plant. Caused by *Plenodomus destruens.*

Scurf. Brownish discoloration or rusting of the skin of the potato, mostly in spots. Caused by *Monilochaetes infuscans.*

Root rot. A dry, firm rot of potatoes in the field; vines injured for a foot or more from the hill. Caused by *Ozonium omnivorum.*

Mottle necrosis. A marbled chocolate-brown discoloration of the interior of the fleshy root. Caused by *Pythium ultimum* and *P. scleroteichum.*

Soil rot. Pits of various sizes on the fleshy roots; black cankers on the rootlets.

Leaf blight. Circular brownish spots on the leaf with many black specks. Caused by *Phyllosticta batatas.*

Leaf spot. Small circular spots on the leaf with one or more black spots. Caused by *Septoria bataticola.*

White rust. A whitish, moldy growth on the under side of the leaf. C by *Albugo ipomoeae-panduranae*

Storage rots:

Soft rot. Watery decay of roots only

Ring rot. Like soft rot, but decay begins between the ends. Caus *Rhizopus nigricans.*

Black rot. Circular black, somewhat sunken spots on the potatoes, va in size. Caused by *Ceratostomella fimbriata.*

Dry rot. A firm, dry rot of roots only. Caused by *Diaporthe batatat*

Java black rot. A firm dry rot of roots only; black within; protuberanc the surface. Caused by *Diplodia tubericola.*

Charcoal rot. A rot of tubers only; black within. Caused by *Scler bataticola.*

XXII

SWEET CORN *(Zea Mays var. rugosa)*

History and taxonomy.—Corn probably originated in Mexico. here is abundant evidence that it was used by ancient peoples of e Americas and the Indians of many regions grew it as their most portant crop.

Sweet corn, however, apparently is of relatively recent origin. is believed to have been unknown in Colonial days. In 1779 a ember of General Sullivan's expedition brought a few ears to ymouth from the Indians of the Susquehanna. The Iroquois ltivated white and black varieties and the Indians of the upper issouri had four sweet corns among the many varieties they anted.

Sweet corn belongs to the grass family, *Gramineae*, which inudes the world's most important crop plants. It and edible bamoo, of which the shoots are eaten, are the only vegetables of the roup; all others are cultivated as cereal or forage crops.

Importance.—In popularity and economic importance sweet orn ranks with such staple vegetables as tomatoes and cabbage. is planted extensively for home use and local markets, for comercial canning, drying, and freezing. Because the quality of weet corn depreciates very rapidly after harvesting, the crop is rown to only a limited extent for long-distance shipping.

Environmental adaptations.—Conditions for optimum develpment of sweet corn are warmth, both night and day, an abunance of sunshine, and fertile, well-drained soil that is retentive of oisture. The plant is easily injured by frost or prolonged cold eriods and by excessive heat or drought.

Sweet corn can be grown in nearly all parts of the country, but xtensive commercial planting for both market and canning is conned to the northern states where yields are heavier and high uality is more readily obtainable. In the South the corn earorm frequently ravages the crop, the bacterial wilt disease is evere, the duration of the best edible stage is so short in the usuly prevailing high temperatures that uniform harvesting is difcult, and quality is lost much more rapidly in course of handling fter picking than in cooler regions.

Sweet corn is grown successfully on nearly all types of soil, proided they are well supplied with organic matter. Well enriched, andy and shaly loams that warm quickly in the spring are preerred for early market growing. For the later market crops and

for canning, larger and more economical yields can be secured wit moderately heavy soils that are more retentive of moisture and les expensive to maintain in good state of fertility.

Rotation and soil preparation.—The most advantageous plac for corn in the rotation is immediately following a good sod or gree manure crop. Fertile soils cultivated the previous year, howeve can be used with success. Manure can be applied to advantag but the present cost limits its use on sweet corn to growers wh keep much livestock.

Fall plowing of sods or well developed green manure often advantageous in northern areas. If plowing is deferred until sprin there should be no delay when an early crop is desired. Turnin

Robson Seed Far

FIG. 127.—Sweet corn is one of the most popular vegetables

e land for later plantings should be completed at least two or three eks before planting time to provide some assurance of uninterpted moisture supply. The drag or pulverizer should be used as on as the ground is dry enough after plowing, and the harrow ould be used often enough to destroy young weeds and to prepare firm but not packed seed bed. For very early planting a comratively loose seed bed will warm more quickly.

Lime.—Sweet corn is more tolerant of acidity than many vegeble crops but maximum yields can not be secured on very acid ils. Liming is likely to prove profitable if the soil is more acid an pH 5.5. Lime should be applied generally before some more nsitive crop in the rotation.

Fertilizing.—With heavy leguminous sods, succulent nongumes, or liberal applications of manure, a few hundred pounds the acre of 4-16-4 or superphosphate may be the most profitable eatment for the main or late crop on moderately heavy soils. In ontrast, 1000 pounds of 5-10-5 to the acre may be required for est results with early corn on light soils. Typical applications for any intermediate situations are 300 to 500 pounds to the acre of -12-4, 4-10-6, or 5-10-5. Under some conditions, usually with the arliest varieties on light soils, top-dressings with nitrogen will pay.

Band applications are most efficient when small or moderate mounts of fertilizer are used. The heaviest applications generally re broadcast in part or whole and worked into the soil before lanting. A popular practice in growing early corn on sandy soils s to apply part of the fertilizer before or at planting time and hen to side-dress with the remainder when the plants are about foot high, cultivating it thoroughly into the soil or placing it in ands below the surface.

Planting.—Growers for the early market often make the first lanting almost as early as the soil can be prepared. Sometimes he seeds germinate promptly and the young plants succeed better han a slightly later planting that happens immediately to precede old, wet weather. Very early plantings, however, always entail onsiderable risk of failure and main crop plantings should not be nade until about a week before the average date of the last killing rost.

To provide a longer season of harvest, several varieties (p. 438) f different degrees of earliness may be planted at one time, or uccession plantings can be made of a preferred variety at intervals f about a week.

A planting depth of an inch or an inch and a half ordinarily is uitable. The covering may appropriately be even more shallow arly in the season, when the soil is cold and moist, and considerably eeper with late plantings on light, dry soils. Germination, partic-

ularly of early plantings, generally is improved by protective treatment with organic mercury dusts (pp. 22, 25).

Spacing must be suitable to the variety to secure the max yield of first-grade ears and few of second grade. The s growing early varieties and Golden Bantam types may stand 12 inches apart in 30 to 36-inch rows. The more vigorous season and late kinds require 36 to 42 inches between the row 12 to 18 inches between plants in the row. Spacing should b eral to produce the finest ears for market and slightly close to the heaviest tonnage for the cannery.

It is thought that yields generally are largest with a ful correctly spaced stand of plants in continuous rows or drills. ertheless, check rows are popular on weedy soils and compa yields can be secured with 2 or 3 plants to the hill and hills 42 inches apart according to variety.

Regardless of the system of planting, thinning should be ticed if the stand is much too thick; many nubbins otherwise be produced. Quite satisfactory thinning can be accomplish severe cross weeding or light harrowing. Hand thinning costly for large-scale operations. A correct stand usually c secured without further attention, however, by using a skillfully lated planter after the soil is warm, although an excess of generally is necessary to assure a full stand from the earliest p ings. It is better to cut off the surplus plants than to disturb o by pulling them.

About 10 or 12 pounds of seed to the acre are the av amounts used. Half as much may be sufficient under favo conditions with some small-seeded hybrid varieties averaging 100 seeds to the ounce and one-half more is not too much unfavorable circumstances and with large-seeded kinds.

Use of plants and plant protectors.—It is possible to sweet corn under glass and transplant to the open ground after d of frost, but the plants are not readily shifted without serious c ing of growth. The expense involved, and the usually small g earliness limit transplanting to home use or special market de Pots or bands must be used to avoid disturbance of the roots. six grains should be started in each container approximately weeks in advance of field planting time. The stand is thinne to four plants and then to two or three after the plants becom tablished in the open.

Plant protectors of semi-transparent oiled or waxed pape used to a very limited extent in producing extra early sweet When they are used, planting may be advanced a few weeks. the seedlings are two or three inches high the tops of the prot

slit slightly to provide some ventilation, and later they are cut in X-fashion to permit the plants to shoot through.

Cultivating.—If there are heavy rains after planting, a weeder or light spike-tooth harrow should be used to break any crust that may form. Weed control is greatly facilitated by using the weeder across the rows when the young corn is coming through the ground and later working with the rows when the plants are a few inches high. This implement may supplement and sometimes even take the place of the cultivator until the plants reach the height of about a foot. An occasional plant will be damaged but the cost of cultivation with a weeder is very low and few weeds succeed in gaining a foothold in the row.

Cultivators should be of the type suited to soil conditions, kinds of weeds, and the acreage of the crop. The important factor is to control weeds with little or no hand-hoeing and to accomplish this without material injury to the corn roots. Deep, late cultivations nearly always are very detrimental. Cultivation of sweet corn, except to control weeds, generally exerts no favorable influence and should not be done after tasselling.

Suckering.—Removal of suckers from sweet corn has been shown to be unprofitable under most conditions and is not generally practiced. The operation is laborious and sometimes reduces yields, especially when the work is delayed until the suckers are large.

On the contrary, certain expert growers of early market corn, under some conditions, particularly in New Jersey, have concluded from their own tests that removal of suckers when the plants are about 12 inches high produces profitable gains in earliness and in yield of first-grade ears.

Harvesting and marketing.—Sweet corn should be picked at the milk stage, that is, as soon as the kernels become well filled and plump, but before the dough stage develops. The duration of the milk stage is variable and may be only a day or two for some varieties in hot, dry weather. Generally about 18 to 22 days elapse from silking to harvest. Harvesting at the best stage helps to assure remunerative prices on the market and a high-grade pack at the cannery. Certain highly bred varieties when well grown may mature the entire crop almost simultaneously and can be harvested at one or at the most two pickings.

Sweet corn is commonly packed in bags, baskets, and crates with a uniform count of 4 dozen, 5 dozen, 100, or some other common or popular number of ears in each package. Grading to the U. S. Standards is an advantage on many markets and the package should be labelled with the count, grade, and grower's brand or name.

...lo vegetable, when packed tightly in containers or handled in ... generates heat more rapidly or loses quality more quickly ... does sweet corn. At temperatures which often prevail, half ... sugar is changed to starch within 24 hours. It follows naturally ... sweet corn should be moved as expeditiously as possible from ... field to the consumers' tables or into the packers' cans and that ... should be kept as cool as possible. The rate of deterioration ... tically doubles with each 18 degrees rise in temperature. At ... F., a common temperature in sacks of corn, the loss is more ... 8 times as rapid as at 40 degrees.

Market growers harvest as near the time of selling as possible, ... erably in the evening when it is cool or very early in the morn... If the corn must be held for several hours it should be spread ... in bulk or in packages in a shady sprinkled place in the packing ... e or beneath large trees.

Increasing numbers of growers precool sweet corn by im... sion in very cold water and use crushed ice either within the ... age or between the containers when they ship by trucks. In ... shipments the best available refrigeration service should be pro... d.

Yields to the acre ordinarily range from 500 to 1,000 dozen for ... ket and from 1½ to 3 tons for the cannery, although record ... ds are considerably higher.

SEED GROWING

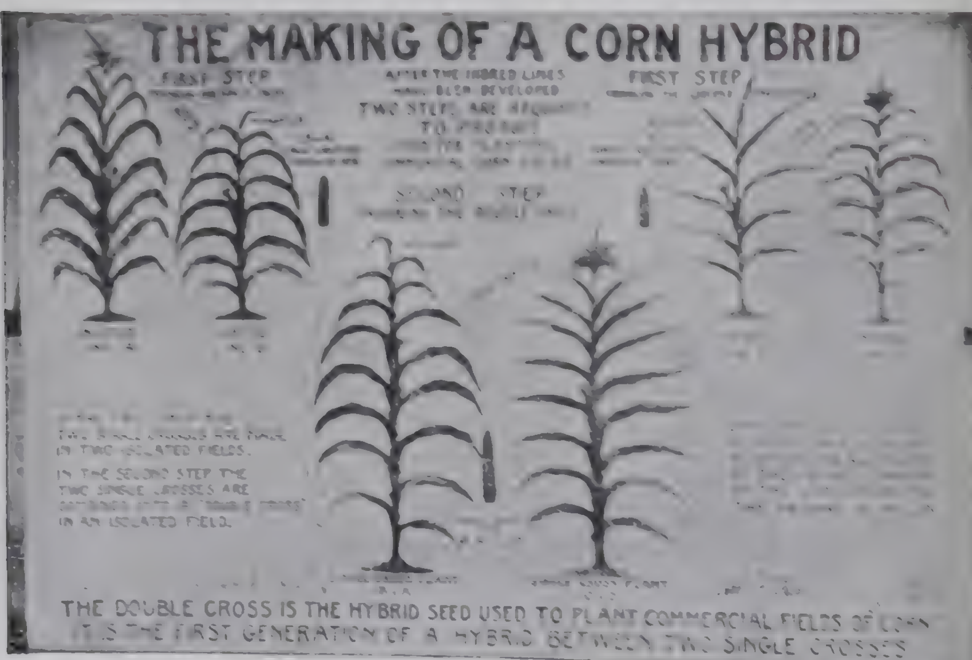
Production of sweet corn seed, involving specialized breeding ... edures, requires careful study of every detail to avoid wasted ... t and disappointment. Literature on the subjects of corn ... ding and better seed corn is available from the United States ... artment of Agriculture and several State Agricultural Experi... t Stations. Brief descriptions of leading methods follow.

Mass selection.—Experienced growers of open pollinated vari... often select seed from the ear and plant types that best suit ... purposes. Notable improvement or adaptation often follows ... in a few years, although improvement may be slow thereafter. ... selection is the best method for the average gardener, but its ... should be restricted to open pollinated stocks.

Ear-to-row selection.—Seed from each of a number of ... cted ears is planted in individual rows. Performance of the sev... progenies in respect to yield and other important characteris... is noted. Further selection and increase of the most promising ... may proceed in several ways. Probably the most simple and ... venient is the remnant method in which part of the seed from ... ear is held in reserve under numbers corresponding to the

rows in the test plot. It is described in Bulletin 1489, U. S. De-partment of Agriculture:

"The remnant seed of the one to three highest yielding ears i used to produce pollen-parent plants, the seed from the second-bes producing ears being used to produce pistillate-parent plants. Thes two lots of seed are planted in such a way that there will be on row of pollen-parent plants alternating with one, two, or three row of pistillate-parent plants (Fig. 130). The latter are de-tassele before they shed any pollen, so that the seed produced on them i pollinated by pollen from the pollen-parent plants. Only the see from the de-tasseled plants is used for general planting, ears bein selected from the general field for another ear-to-row plat."



Ohio State University

FIG. 129.—The making of a corn hybrid.

Production of hybrid seed.—Crossing generally secures in-creased vigor in the first generation, but corn is so largely cross-fertilized that usually little advantage is gained with ordinary varie-tal combinations. Remarkable increases in productivity and uni-formity of the first generation, however, have followed the crossing of certain lines previously inbred for several generations. Thus Golden Cross Bantam and other notable F_1 (first filial generation) hybrids have been developed (Fig. 129).

The production and testing of inbred strains and their combin-ations are highly technical, intricate, and very expensive undertak-ings. The increase and maintenance of pure inbred lines of proved

orth are less difficult but demand complete isolation to prevent eterioration. A corn grower contemplating the production of seed or a F_1 hybrid variety should consult his experiment station for ecommendation of parent stocks and their sources.

Crossing is accomplished, in Golden Cross Bantam for example, by planting single rows of Purdue inbred 51, the pollen parent, alernately with groups of usually 4 rows of P39, the seed parent. At their first appearance all tassels must be removed daily from both main stalks and tillers of the seed parents before pollen can be shed.

Associated Seed Growers, Inc.

FIG. 130.—Crossing field in the production of hybrid sweet corn seed. The lighter rows are the pollen parents; the darker rows, which will bear the hybrid seed, have had their tassels removed. Frequent and complete detasseling is necessary to secure pure seed.

Delay or carelessness will seriously impair the quality of the seed produced. It is obvious that seed value in crossed corn is more than ordinarily dependent upon the thoroughness and integrity of the producers. The average grower of sweet corn will find that the cost will not be greater and that he will secure equally good or better seed of hybrid varieties by purchasing from reputable, specialized producers. It may be emphasized that seed saved from F_1 hybrid plants, Golden Cross Bantam for example, usually produces a crop, the F_2 generation, that falls off 15 or 20 per cent in performance.

The so-called "top-crosses" are made by planting an inbred pollen parent of proved value alternated with a good open pollinated variety for the seed parent, the procedure in other details

being the same as described. There are many excellent top-cross combinations. They are slightly less uniform than F_1 hybrids but also less expensive to produce because only one selfed or inbred parent stock is required.

Curing seed.—Prompt and thorough curing is required to insure high germination and vigor in sweet corn seed. The ears can be gathered any time after the kernels begin to wrinkle.

Circulation of air around every ear, and perhaps artificial heat in addition, may be necessary to dry the corn before it molds. Small quantities can be cured anywhere if proper conditions are provided. The ears generally should be supported individually on nails, pegs, or strings. With the best air circulation they may be cured in racks with the layers not over 2 or 3 ears deep. Seedsmen use special curing barns and some of the best seed is dried artificially in about a week by means of special drying equipment.

VARIETIES

Sweet corn varieties may be classed as early, second early or midseason, and late in accordance with the time required to attain edible condition. This ranges from approximately 70 to 100 days. In general the early varieties grow only 4 to 6 feet high, require liberal fertilization, and are more subject to disease than are the stronger growing midseason and late varieties which are 6 to 10 feet tall.

Both white and yellow varieties are available in various seasons of maturity and the choice is determined by market preference. Yellow corn, however, is gaining in popularity, even for canning, where the white kinds formerly predominated.

It is convenient to discuss the open pollinated varieties and first germination hybrids separately.

Open-pollinated varieties in general succeed under a wider range of conditions. The same diversity of inherited characters which makes the crop less uniform indicates that at least many of the plants may escape temporarily adverse conditions, such as high temperatures and low humidity at the period of pollination.

Before suggesting varieties it should be emphasized that the earliest members and derivatives of *Golden Bantam* within the open-pollinated group generally are very susceptible to bacterial wilt or Stewart's disease. Except in the cooler sections of the northern states, they sometimes fail completely on this account. The late varieties, especially the white, are quite resistant.

Popular white open-pollinated varieties in approximate order of earliness are: early, *Early Market*, *Surprise;* second early, *Whipple Early*, *Vanguard*, *Howling Mob;* late, *Early Evergreen*, *Country*

Gentlemen (Shoe Peg), Narrow Grain Evergreen, Stowell's Evergreen, and *Long Island Beauty.*

Well known open-pollinated yellow varieties are: early, *Golden Gem (Nugget), Spanish Gold, Golden Early Market, Sunshine, Extra Early Bantam;* second early, *Golden Bantam, Whipple Yellow;* late, *Bantam Evergreen, Golden Colonel* or *Golden Country Gentlemen (Golden Shoe Peg).*

Adams Early, Trucker Favorite, Silvermine, Snowflake and similar varieties are not true sweet corns but resemble field corn. Of fair quality when young, they are valued for vigor, hardiness, and the well developed husk which affords some protection from the ear worm. Planting of these varieties is limited mainly to the South and considerable quantities are shipped.

First generation hybrids.—Because all the plants of a certain combination are genetically alike, some hybrids that are particularly adapted to one set of climatic conditions may be unsuited to another. The characteristics of others may enable them to succeed over a wide range. General adaptation must include resistance to disease, which hybrids of certain parentages exhibit in marked degree while others may be very susceptible. In general F_1 hybrids are especially desirable for canners and other commercial growers

Rovson Seed Farms

FIG. 131.—Golden Cross Bantam, F_1 hybrid, established new standards of uniformity in plant, ear and maturity. With high quality, wide adaptability, strong resistance to wilt, and great productivity, it revolutionized the corn canning industry and became the standard of comparison among yellow varieties.

because the nearly simultaneously maturing of the entire crop lo ers the cost of harvesting and assures a more uniform stage of velopment with higher average quality and fewer overmature immature ears left in the field.

Early to second early yellow F_1 hybrids and top-crosses are merous. Not all are generally adaptable; some are resista others susceptible to Stewart's disease, and variations in quality considerable. A partial list of promising hybrids in approxim order of earliness is as follows: *Spancross* C2, *Marcross* 13.6, *Sen Golden, Sencross, Bancross, Kingscrost, Spancross* P39, *Marcr* P39, *Whipcross* C6.2, *Carmelcross* P39.C13, *Whipcross* P39, *Gol Cross* 2.

Golden Cross or *Golden Cross Bantam* is the outstanding seco early or midseason yellow F_1 hybrid. It is later than the origi *Golden Bantam*, more vigorous, highly resistant to Stewart's d ease, and very widely adaptable. Kernels are of medium size a high quality. When well grown from uncontaminated seed, *Gol Cross* is phenomenally uniform in plant, ear, and simultaneity ripening. *Top-cross Bantam* is similar, slightly less uniform, a adapted to the same purposes. *Golden Hybrid* or *Evergreen H brid* is slightly later. Other valuable hybrids and top-crosses appearing.

Hybrids and top-crosses of white sweet corn have been veloped mainly in late or canning types. *Redgreen* and *Stow Evergreen Hybrid* are best known. Redgreen is best adapted New England conditions.

Because of the notable differences in adaptability of many swe corn varieties, small-scale trials should precede extensive planti of any new introduction into a locality.

INSECTS

Control of the European corn borer, cutworms, wire worms, ar other general crop insects, is discussed in Chapter X.

The seed corn maggot is considered on page 398.

Corn earworm (*Heliothis obsoleta*).—The adult moths emer in late spring and summer and deposit eggs on the silk. In 3 to 1 days the larvae hatch and feed down the silk into the kernels. Th same insect, familiar as the cotton bollworm, tobacco budworm, an tomato fruitworm, also feeds on several uncultivated plants. Cons quently, crop rotation is of no avail. Injury is generally severe i the South and progressively diminishes northward.

On a small scale, the silks may be dusted with a mixture of equ parts of flour or fine dusting sulphur and an arsenical or with ro enone dust. The first application should be made as soon as th

appear, and about two more dustings should follow at 5-day rvals. A plunger or knapsack duster is most efficient, although mall gardens, the material can be shaken into the silks by any venient means. Another method is to clip the silks and husk tips scissors within two or three days after the silks appear. The ration must be repeated within a few days. The recently devel-l and more promising mineral oil treatment is described in Circ-190 of the Geneva New York Agricultural Experiment Station. Losses in commercial plantings can be reduced to a considerable nt by fall plowing to destroy full-grown larvae that pupate in soil, by selecting varieties with long, tight husks that will resist attempts of the larvae to enter, by early planting to escape the period of most concentrated egg laying, and by late May plant-so that the crop will silk during the period of summer pupation ween the first and second broods.

DISEASES

Corn smut (caused by *Ustilago zeae*).—This disease is familiar black puffy masses affecting ears, tassels, or other parts of the nt. Early removal and burning of diseased parts, to check the emination of spores, may be worth while under some conditions. lpful preventive measures include rotation, use of clean manure, the avoidance of the more susceptible varieties, particularly e of the extra early, open-pollinated yellow types.

Stewart's disease or bacterial wilt (caused by *Aplanobacter warti*).—In the warmer parts of the sweet corn growing regions disease often causes serious losses and may result in complete ure of very susceptible varieties.

The bacteria invade the fibro-vascular or conducting system of plants, interfere with the movement of solutions, and cause wilt-. Depending upon the degree of infection, the plants are slightly everely dwarfed, leaves wither or die, more or less premature eling and ripening occur, and the general appearance is similar hat in times of extreme drought. If a diseased stalk is cut off r the ground, sticky, yellowish droplets will ooze from the vessels.

The most important and only fully effective means of control are plant resistant varieties of which excellent ones are available.

Because flea beetles, cucumber beetles, and certain other insects ead the disease from plant to plant with great rapidity, and in e cases probably carry the bacteria over winter, seed treatment erally is ineffectual, especially where the organism is established.

Root rots, as commonly termed, are caused by a number of or-nisms which may attack the plant at any stage of its development. "seedling blight" they often cause poor stands from early plant-

ings. Affected knee-high plants will be more or less off color, stun and spindling, with rotting of the early roots and interior of the of the stalk. Later, tasseling and silking are delayed, wilting re. occurs, diseased stalks lean or fall, and many ears hang dow diseased or rotten shanks.

Control consists of selecting disease-free ears—those from mal stalks and without discoloration of the cob-butts,—seed te and rejection of diseased ears, proper fertilization and rotation, seed treatment with organic mercury dust before planting 22, 25).

XXIII

CUCURBITS

CUCUMBERS, melons, pumpkins, and squashes belong to the ily *Cucurbitaceae.* General characteristics and several phases culture are sufficiently similar to permit their discussion as a up. Matters pertaining particularly to the different crops are sidered separately.

Climatic requirements.—The cultivated cucurbits are annuals d succumb to light frost. All of them require warm weather. mperatures of 75° to 85° F. are especially favorable. The umber and summer squash first attain marketable stage in 50 to days, whereas muskmelons and watermelons require approxitely 80 to 100 days, and winter squashes and pumpkins must ve 100 to 120 days. Twenty to 30 additional days or more of owing weather are necessary to mature a full crop. Cucumbers d squashes thrive in frost-free but cool weather. The melons ed more heat than the others and are more sensitive to unfavorable nditions.

Soil preferences.—Sandy soils or light warm loams are best for e melons and for cucumbers and squashes when earliness is the ief consideration. Moderately heavy loams in good tilth, or light ams with clay subsoil, however, assure a longer bearing season for cumbers and are preferred when this crop is planted for later arket and for pickling. Similar soils are favorable for winter rieties of squash.

Whatever the type of soil, it should be well drained but of high oisture-holding capacity unless irrigated. It should also be abunntly supplied with organic matter, in various stages of decomposion, to retain moisture, release nutrients, and promote aeration. evelopment of the cucurbitous crops proceeds with remarkable pidity under favorable conditions, creating demands which require e most skilful soil management so that the plants will not lack at y time an adequate supply of moisture and nutrients.

Soil preparation.—Timely plowing and successive harrowings efore planting are advantageous. When possible a sod or green anurial crop should be grown to plow down in the spring, but it ould be turned under at least a week or two before planting. ermination is often poor when the seeds are planted very soon after eat amounts of fresh organic matter are plowed down (p. 90).

When preparing to plant, some growers prefer to throw the land to slight ridges, thus securing better drainage and providing some-

what warmer soil. A potato planter will apply fertilizer and make suitable ridges at the same operation. On areas where drainage sometimes is troublesome the situation is improved by bedding, in which two or more furrows are thrown together to make beds or lands of the required width, with open furrows between to facilitate the escape of excess water.

Lime requirement is medium for muskmelons, medium to low for cucumbers, squashes, and pumpkins, and low for watermelons. In fact, liming for the watermelon crop may be harmful unless the soil is strongly acid. The pH ranges are tabulated on page 508.

Use of manures.—Large yields of high quality are greatly favored by constant, unchecked growth, accomplished by providing proper physical as well as nutritive conditions of the soil. The roots attain best development in soils abounding in vegetable matter. For this reason, stable manures have been found particularly valuable. They should be well decayed, unless applied a month or more in advance of planting. If the supply of manure is abundant, it may be applied broadcast, but it will go further and produce greater results in soils of moderate or low fertility when applied in the hills or furrows. A popular and successful practice among market growers is to open the furrows if possible about a month before it is time to plant, distribute the manure, then turn back the soil. Some growers first mix soil and manure thoroughly in the furrow with any convenient tool and then turn back the soil. When planting is in hills a shovelful or two of manure is placed in each hill and usually mixed with the soil. Poultry manure should be used much more sparingly.

Stable manures unquestionably are effective for cucurbits and no group of crops is more responsive to their use. Many extensive and very successful growers, however, depend upon leguminous sods or green manures, or even non-leguminous crops, in connection with appropriate applications of fertilizer nitrogen, in some cases as a pre-plowing application to the soil improving crop (pp. 80-91).

Unless manure is used plentifully, 10 or 15 tons to the acre, the cucurbits in the rotation always should follow a soil improving crop.

Fertilizing.—If rotted manure is used freely the most profitable treatment is likely to be 200 or 300 pounds to the acre of superphosphate, or a mixture such as 4-16-4, applied with the manure in the rows or hills.

Where manure has been broadcast or a legume has been plowed down, 300 to 500 pounds to the acre of 4-16-4, 4-12-4, or 3-12-6 are likely to be adequate.

On very sandy soils, and without manure or legumes, 750 to 1000 pounds or more of 4-10-6 or 5-10-5 may be required.

Amounts in excess of 500 pounds to the acre generally must be broadcast to avoid injury to the germinating seed, although con-

siderably larger amounts can be used with safety in rows made up, as with a potato planter, sometime in advance of planting. Greatest efficiency with ordinary amounts is secured when the fertilizer is placed in the soil along the rows, or around the hills, at a distance of 2 or 3 inches from the seeds.

Side dressings of 100 to 200 pounds to the acre of nitrate of soda, or the equivalent, often can be used to advantage whenever the vines are likely to be checked by cold, wet weather or by temporary exhaustion of readily available soil nitrogen. Skilful side-dressing with nitrogen, plus potash in some cases, often may be the means of prolonging the bearing period and of improving form, color, and quality of the fruits. Several applications, the first when the vines begin to run, may be profitable on very porous soils.

Cultivation.—The cucurbits are characterized by shallow, widely ramifying root systems and the vines will not withstand rough usage. Cultivation should begin as soon as the rows can be followed and should be as close as possible without disturbing the delicate young plants. At this stage the soil may be worked to advantage rather deeply if it has become too compact. Subsequent cultivations should be as shallow as possible for the practical control of weeds, and must be timely and frequent lest the vines spread so rapidly that many weeds cannot be reached with the cultivator but must be removed by hand, which is laborious and expensive. Cultivation should be managed with minimum disturbance of vines and so that hand-turning of the vines will not be necessary. After the vines begin to creep into the middle spaces the cultivator invariably should run the same direction on the row always to turn the tips the same way. With the best cultivation, considerable hand-hoeing and weed pulling may be necessary, especially with very liberal manuring and fertilizing.

Pollination.—With a few exceptions, staminate (male or "false") flowers and pistillate flowers are borne separately on the same plant, the staminate flowers appearing first near the bases of the stems. Insects generally are present in sufficient numbers to effect adequate pollination. If bees are scarce in the locality, however, or few are visiting the blossoms on account of more attractive bloom nearby, it very likely will prove profitable to place one or more hives at the edges of the planting, especially when the field is very large.

Plant growing.—Muskmelons are the most commonly transplanted cucurbitous crop, but the practice is applied also, to a limited extent, in growing the others when earlier maturity is very advantageous or necessary.

Advantages, when the plants are properly grown and handled, are gain of one to two weeks in earliness, increased yields, and a shorter period of warfare with the cucumber beetle. Transplanting

cucurbits, however, is a specialized practice of considerable local importance which is unsuitable as well as unnecessary for most circumstances.

Because the young plants are extremely sensitive to root disturbance they can be transplanted successfully only when properly grown in suitable containers, such as pots or veneer bands. The bands usually are most satisfactory (p. 453).

Soaking may be necessary so that the bands can be shaped more readily without breaking at the scorings. The bands, usually of 4 or 5-inch size, are placed as closely as possible in the plant bed or bench, filled nearly one-half full of fine, thoroughly rotted manure, and finally filled level-full with well prepared plant-growing soil, slightly firmed in place.

The seeds should be sown not more than a month before the time for transplanting to the field, for if too far advanced the plants may become crowded and suffer a check in growth when transferred. Six to eight seeds are planted in each container. When the center buds appear the plants are thinned to the three strongest, and the weakest one of these is removed a little later, preferably with a knife to avoid root disturbance.

Temperatures of 70 to 75 degrees are desirable during germination. Thereafter night temperature of 60 degrees and cloudy day temperatures not execeeding 70 degrees are favorable to sturdy yet uninterrupted growth. Very slight hardening by moderate watering, freer ventilating, and slight lowering of temperatures is customary during the last few days or the week before planting in the open.

Plant protectors, usually made of oiled paper and of several forms, are used extensively in the Southwest and to a more limited extent in humid regions to start melons and occasionally the other cucurbits.

Forcing boxes and plant protectors are discussed later (pp. 454, 478).

Frame culture.—Cucumbers, muskmelons, and summer squash sometimes may be grown for a considerable part of their period of development in hotbeds or coldframes, thereby securing an extremely early crop for the locality. The method is of considerable importance in some localities and is common among market gardeners. The crop may be started from seed sown in place or from plants grown as previously described. General suggestions for frame culture and the forcing requirements of cucumbers are found in Chapter XXV, and later in this chapter (pp. 457, 478, 495). Construction and management of hotbeds and coldframes are considered in Chapter IV (p. 28).

Irrigation is essential in arid regions, and growers in humid regions find many occasions when water can be applied at a profit.

The furrow system is generally used where topography permits. Although the cucurbits demand a continuous supply of moisture and suffer readily from drought they are easily injured by excessive rainfall or irrigation. Frequency and amount of irrigation must be skilfully regulated in accordance with the needs of the particular crop, the soil and atmospheric conditions, and the stage of growth. Moderate and sufficiently frequent irrigations are preferable to infrequent heavy soaking. The watermelon is less insistent than the others in the demand for water.

Seed growing, Insects, and Diseases are considered in the latter part of this chapter, following the special discussions for the several crops.

CUCUMBER (*Cucumis sativus*)

History and importance.—The cucumber is one of the oldest of the cultivated vegetables, probably a native of India. There are records of its cultivation in Western Asia more than 3,000 years ago and in ancient Egypt and Greece. The crop was introduced into Europe by the Romans and Columbus found cucumbers in Haiti in 1494. The Indians near what is now Montreal were found growing them in 1535.

Cucumbers are produced on a large scale for shipment and for pickling. They have a place in nearly every home garden and market garden. This crop is second in importance among the vegetables produced under glass.

Adaptations.—The cucumber can be grown at some seasons under a wide range of climatic conditions. All the trucking sections of the South and of the Atlantic Coast are favorable for the production of the early crop, while the cooler summers of the North are well adapted to growing both slicers and picklers. The plants are sensitive to frost as well as to extreme heat, but thrive under cooler conditions than do the melons. Because of the short period required to mature the crop, there are very few sections of the United States where it cannot be grown successfully.

Light sandy soils are best for the early crop, but yields are larger and the bearing is longer on heavier soils. The cooler clay loams often are used for the late crop and for the growing of picklers. Whatever the type of soil, it should be retentive of moisture but not wet.

Planting.—Planting should not occur until the ground is warm and there is practically no danger of frost. Some growers plant seed at two different depths, the shallow plantings coming on first, and, if these are killed or damaged by frost, the later ones will be likely to escape. For the main or pickling crop in the North, June

For pickles the black-spine cucumbers are preferred, by the grower for earliness, long season of production, and prolific setting of fruit, and by the manufacturer for superior solidity, form, and color. Outstanding varieties are *National Pickle (Association Pickling)* for small pickles, and *Chicago Pickling* for medium pickles. Other popular sorts are *Boston Pickling (Green Prolific)*, *Snow Perfected Pickle*, and *Jersey Pickling*.

West India Gherkin, *Cucumis Anguria*, is a different species from the cucumber. Its principal use is for very small pickles and culture is similar to that of cucumbers.

For slicing cucumbers the white spine varieties are more suitable and of considerably larger size at the best edible stage. *White Spine*, a very old variety, is early and hardy but short and of comparatively light color. It has been largely superseded by its derivatives and numerous crosses. Outstanding commercial names include *Kirby (Stay Green, Black Diamond)*, *Early Fortune*, *A & C (Ace)*, *Straight 8*, *Clark Special*, *Woodruff Hybrid*, and *Perfection*. The varieties named first in this list are slightly shorter and earlier than the others. *Longfellow*, latest of the common white spine varieties, is distinct from *Long Green*, a large-growing, black spine, home garden variety.

Deltus, *Abundance*, or *Irondequoit*, similar hot-house strains, are late, long, cylindrical, and dark green.

The English varieties, which are characterized by extremely long, cylindrical fruits and their ability to set fruit without pollination, are grown in this country to a very limited extent in private estate greenhouses, and by plant breeders for use in crossing to combine free-setting or other characters.

MUSKMELON (*Cucumis Melo* var. *reticulatus*)

History and importance.—The muskmelon, as known today, is thought to be a derivative of wild forms native to India. Often called cantaloupe, it is distinct from the true cantaloupes which are characterized by rough, scaly or warty, hard rinds. The muskmelon was highly developed in the regions of Asia Minor and the Mediterranean as early as the beginning of the Christian Era. Like the cucumber it was brought to the New World by Columbus and was soon cultivated by the Indians as far north as the St. Lawrence River.

Melons of diverse kinds have been cultivated from fairly ancient times; extensive commercial culture of the muskmelon, however began late in the last century, with the introduction of improved netted varieties suitable for shipment and commonly called cantaloupes in the produce trade. Today muskmelons are one of the im

portant truck and garden crops available in the markets during about half of the year.

Taxonomy.—Whereas cucumbers generally bear small spiny warts, these are lacking in the melons of the same genus, *Cucumis*. The species *C. Melo* includes a number of sub-species. The commercially important ones in this country are: *Var. reticulatus*, the netted nutmeg melons or muskmelons; *Var. inodorus*, the winter melons familiar as the Casaba or Honey Dew varieties, and the Persian melons which are considered distinct by some authorities. Others of interest chiefly as novelties are: *Var. flexuosus*, snake melon or serpent cucumbers; *Var. acidulus*, cucumber melon; *Var. chito*, garden lemon or vegetable orange; *Var. dudaim*, pomegranate melon or Queen Anne's pocket melon; *Var. cocomon*, Oriental pickling melon. *Var. cantaloupensis* has been mentioned. *Var. saccharinus*, sucrins or pineapple melons, are oblong and netted, merging into *Var. reticulatus*.

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FIG. 133.—Delicious muskmelon, an earlier variety of Bender type.

Adaptations.—The muskmelon is much more susceptible to the effects of cold than is the cucumber or the squash. It will not stand frost and demands rather high summer temperatures for most satisfactory results. As a commercial enterprise the crop has been grown most extensively in regions where the seasons are long enough to mature the fruit from seed planted in the open ground. While this is true, hundreds of acres are produced in some sections from plants started under glass. The arid regions of the West produce, under irrigation, melons of excellent quality which are shipped in great quantities to the eastern markets. While climatic conditions

of the West are considered unusually favorable, eastern growers have the advantage of close proximity to the markets. By allowing their melons to ripen on the vines before marketing, they secure equally good quality and are enabled to compete successfully. Irrigation or well distributed rainfall is essential wherever the crop is grown, but warm and moderately dry weather is most favorable during the ripening period of the crop.

The character of the soil is probably secondary in importance to climatic conditions. Sandy types, however, are preferred because they produce an earlier crop, and are easier to cultivate than are heavy ones. Nevertheless, silt and even clay loams often are used successfully in the culture of this crop when proper additions of organic matter are made. In any soil, a constant and fairly liberal amount of moisture is important throughout the season. Drought or insufficient soil moisture invariably results in weak vine growth and in small fruits of inferior quality. Thorough drainage also is important.

Soil preparation and fertilizing have been discussed for the cucurbits as a group. It may be emphasized, however, that muskmelons are exacting, the most sensitive of all to poor physical conditions, inadequate nutrition, and small moisture-holding capacity. Good aeration and high fertility are necessary for vigorous root development and for rapid growth early in the season, which are important factors in securing large yields. Land which has been previously cropped with legumes, or heavily manured for other truck crops the preceding year, is regarded as excellent for muskmelons. Early preparation is desirable. The plowing should be as deep as the soil permits in most cases, and the land should be harrowed at proper intervals until time to plant.

As indicated, stable manures are especially effective in growing the cucurbits, particularly when composted and applied in the hills or furrows previous to planting. When large quantities are used, part should be applied broadcast and part in the row. Supplemental use of fertilizers with both manures and cover crops has been described. It is generally considered advantageous to supply about half the nitrogen from an organic source. On light or thin soils systematic side-dressing may be required for best development.

Planting.—Neither plants nor seeds should be risked in the field until the ground is thoroughly warm and there is no danger of frost. When the plants have been started under glass they must be shifted to the field very carefully so that roots and the soil about them will not be disturbed. When this is accomplished there will be little if any check in growth. If the plants are watered freely, 5 to 10 hours before transplanting, the soil will hold together better during the transfer. The corners of berry baskets and dirt bands which

stick should be cut out with sharp knives at the hills in the field. In removing the plants from pots, one hand should be placed over the pot, with the stems of the plants between the fingers, and the pot then should be inverted and tapped gently to separate soil and roots from the sides. When planting is done in the field the soil is drawn to the balls, cubes, or blocks of earth, downward pressure being avoided because this would disturb the roots. Plant growing is described earlier in this chapter.

Muskmelons are planted in both hills and drills. The hill system makes it possible to cultivate more thoroughly and is more popular in many of the largest producing sections. Drilling, however, is favored by many of the best growers. With either method rows generally should be about 6 or 7 feet apart, and for cross-cultivation the hills may be 3½ to 6 feet apart in the rows.

The depth of covering varies from 1 to 2 inches, depending upon the character of the soil. It is best to use plenty of seed, about 10 to the hill, in order to be certain of a good stand. From 1 to 3 pounds of seed are required to the acre. Some growers make two or three plantings in the hill or the furrow, at intervals of a few days, to insure a good stand. Frost may injure or destroy the first lot, but the later plantings will escape. If some seeds are planted deep and

New Jersey Agricultural Experiment Station

Fig. 134.—Muskmelon plants started in veneer bands, ready for the field.

others shallow a good stand will result whether subsequent conditions are wet or dry. Mulching aids during a drouth (p. 121).

Thinning (p. 448) should be deferred until the plants become well established, but undue crowding must not be permitted. Two plants generally are left in a hill, but it is the opinion of many expert growers that one plant is enough. Two feet between plants in the row is about the minimum to avoid excessive overlapping of vines, and 3 or 4 feet to the plant is not too much under many conditions. Crowding decreases the size of the melons, increases the percentage of culls and favors disease.

Use of plant protectors and forcing boxes has been mentioned. The following detailed suggestions for the construction and management of forcing boxes are from New Mexico Agricultural Experiment Station Bulletin 63:

"These boxes may be made from inch lumber, 8 x 10 x 12-inch, with a groove for a 10 x 12-inch glass. The cantaloupe seed is planted in the field as early as possible in the spring and the glass-covered boxes are placed over the hills; at the station the seed has been planted as early as March 25.

"The seed soon germinates and the plants grow right along without being injured by the low night temperature. If it can be so arranged, it is desirable to have the boxes sloping slightly to the south and the east. After the plants have come up care should be taken in ventilating. The general practice of some growers is to remove the box in the forenoon, and in the afternoon to replace it. Others simply pull the glass out a few inches. The latter method seems to be better, for the reason that the plant gets plenty of air and at the same time is protected from the cool and hard winds that are likely to blow during the day. The boxes are removed after all danger of frost is over. The plants should be hardened before the boxes are removed." (See also pages 446 and 478).

Harvesting.—Experience is required to decide just when a melon has attained maximum quality, or the most favorable stage of maturity for the proposed method of marketing. The more important indices are changes in ground color and in color and degree of netting, cracking about the stem, softening at the blossom end, and the slip stage or readiness with which the fruit will part from the vine. The "full slip stage," in which the entire fruit stalk separates cleanly from the melon, indicates full maturity. The "half slip stage," in which a piece of the stem adheres to the fruit, indicates near maturity. The signs of ripening vary with varieties, but one soon learns to recognize the general appearance of melons at the desired stage of development. To secure uniform ripeness harvesting should be done over the whole plantation every day in warm weather.

The importance of suppiying high quality melons can scarcely be overemphasized in the interest of the individual grower or of the melon industry as a whole. Quality which tends to be elusive and variable, particularly as the melons reach the consumers, is sacri-

ficed by picking too soon. It is notable that melons which ripen upon defoliated vines, whether such defoliation has resulted from diseases, insects, or frost, generally are very disappointing in quality.

When the melons can be allowed to ripen quite fully on the vine, some growers prefer to grade into different baskets, as picking proceeds, thereby eliminating subsequent sorting and bruising of the ripe fruits. Melons for shipment are more firm and can better withstand the handling incidental to standardized grading. Water-wax is employed to a considerable extent for coating melons shipped from the Southwest. The apparent advantages are: less evaporation, less decay, and brighter appearance (p. 190). Pre-cooling often is practiced, and careful refrigeration is essential for long distance shipments. Crates and baskets of various kinds are used.

Marketing of shipped melons proceeds by the usual channels, but an unusually large part of the muskmelons grown in the northern states is distributed directly to the retailers and to the consumers. Enormous quantities are sold through farmers' curb markets and roadside markets. Thus, the melons can be harvested when almost or fully ripe and reach the consumer's table with highest quality. Furthermore, because of the perishable nature of muskmelons, direct-to-consumer selling tends to be advantageous, as relatively high retail prices are received, often double the wholesale quotations. Near most of the cities and towns of the northern states there are growers who cater to consumers and grocers.

Average yields of well grown muskmelons are about 150 crates to the acre. Yields of 200 to 300 crates or 500 bushels are not uncommon with the best culture and favorable weather.

Shipping varieties.—*Netted Gem* or *Rocky Ford, Eden Gem, Pollock 10-25, Perfecto* and other closely related green-fleshed or salmon-tinted strains, and *Hale Best,* salmon-orange fleshed, are the outstanding shipping melons most extensively planted in the West and South. *Powdery Mildew Resistant Cantaloupe No. 45,* developed from a cross of Hale Best and a resistant Indian melon, has solved a serious disease problem in the Southwest. All are comparatively small, nearly round, densely netted, and well adapted to crate-packing and distant shipping. Hale Best is earlier than the others.

Local-market varieties for the northern melon grower must be chosen with respect to length of warm season, distance to market, flesh color, other market preferences, and edible quality as determined by aroma, flavor, sweetness, and texture.

The discussion that follows is by Enzie, in Circular 151, Geneva, New York, Agricultural Experiment Station:

"The choice could easily be confined to about eight varieties. For the past 15 years at least 80 per cent of the melons grown in this State have been *Bender*

or a similar type, such as *Irondequoit*, *Delicious*, and *Milwaukee Market* Considerable acreage is devoted to *Champlain* in those areas where the growing season is too short for the later varieties.

"The following constitute the important varieties grown in New York, and are arranged in order of their maturity:

"*Emerald Gem.—Plant* lacks vigor, slender vines. *Fruit* small, about pounds, broader than long, somewhat flattened at the ends, distinctly ribbed. Skin dark green, turning brownish yellow when mature, sparsely, delicately and irregularly netted. *Flesh* salmon yellow, medium thick, soft, juicy, slightly fibrous, very sweet, fine. Poor keeper. *Season* very early.

"*Golden Champlain.—Plant* lacks vigor, slender vines. *Fruit* small, 2 to pounds, globular, slightly flattened at the ends, fairly prominent ribs, blossom scar small. Skin greenish mottled, later becomes orange colored, sparsely, rather delicately, and occasionally unevenly netted. *Flesh* salmon, medium thickness, firm, slightly fibrous, very sweet and rather highly flavored, good quality. Fair keeper. *Season* very early.

"*Extra Early Osage.—Plant* moderately vigorous. *Fruit* medium size, 3 to pounds, oval to somewhat heart-shaped, shallowly ribbed. Skin dark green, later becoming mottled with orange yellow, unevenly covered with delicate netting. *Flesh* orange, thick, fairly firm, small amount of fiber, sweet, good quality. Tendency to crack in wet weather. *Season* early.

"*Delicious.—Plant* moderately vigorous. *Fruit* medium to moderately large, 4 to 6 pounds, usually globular and somewhat flattened at the ends to short oval in shape, shallowly ribbed, blossom scar medium size. Skin light creamy yellow, more uniformly netted with lighter cork than the Bender. *Flesh* orange yellow, moderately thick, tender, sweet and good quality. *Season* early to second early.

"*Milwaukee Market.—Plant* very vigorous, somewhat susceptible to disease. *Fruit* medium to moderately large, 4 to 6 pounds, nearly round, shallowly ribbed. Skin golden yellow, uniformly and rather heavily netted. *Flesh* deep salmon, thick, soft, juicy, often rather fibrous, very sweet and very high quality. Poor keeper, blossom end becomes soft rather quickly. *Season* early to second early.

"*Bender or Bender's Surprise.—Plant* moderately vigorous. *Fruit* large, 7 to 8 pounds often 9 to 10 or more, usually oval in shape, often globular, prominently ribbed, blossom scar very large and prominent, skin yellow, more or less coarsely netted. *Flesh* deep orange, very thick, small amount of fiber, sweet and high in quality. *Season* second early.

"*Irondequoit.—Plant* vigorous. *Fruit* large, 8 to 10 pounds, globular, somewhat flattened at the ends, moderately ribbed, blossom scar moderately small. Skin creamy yellow, moderately well but coarsely netted. *Flesh* salmon, thick, soft, sweet, high quality. Poor keeper, tendency to crack at blossom end. *Season* second early to midseason.

"*Hale's Best.—Plant* medium vigor. *Fruit* small to medium size, 2 to 3 pounds, short oval to round, ribs and sutures practically absent, skin dark green, later brownish green, entirely covered with medium heavy closely laced netting. *Flesh* salmon orange, very thick, firm, medium coarse texture, highly flavored, excellent quality. Good keeper. *Season* midseason to late.

"*Hearts of Gold.—Plant* medium vigor. *Fruit* small to medium size, 2 to 3 pounds, nearly round to somewhat heart shaped, tapering at the blossom end, shallowly ribbed, sutures smooth and prominent. Skin dark green, uniformly covered with fine lace-like netting. *Flesh* deep orange, very thick, firm, fine texture, sweet, highly flavored. Excellent quality. Good keeper. *Season* midseason to late."

Among promising new varieties *(Honey Rock) Sugar Rock* is similar to Hale Best "being much less finely netted, with much

paler green skin color and a thicker, darker green shell." *Aristocrat or Golden Combination,* is described as follows: "The fruits are nearly as large as Bender, more uniformly netted, and have the greyish-green skin color of Sugar Rock. The orange flesh is very thick, juicy, and of good quality. Tests so far have shown it to be slightly later than Bender and somewhat less prolific."

Frame culture.—In the Montreal section the muskmelon crop is grown almost to maturity in sash-covered hotbeds with movable frames. The synopsis of procedure which follows is made from publications of the Vermont Agricultural Experiment Station. It is included for suggestions in the frame culture of cucurbits in general, as well as for guidance of those who may undertake the exact method. A somewhat less elaborate and not so highly specialized system, however, is more common.

Plants are started in the greenhouse or hotbed in March or early April. The frames are movable sections, approximately 12 by 6, strong and tight, with tie rails for the sash to slide upon. The soil over which these sections are set is ridged up in beds 12 to 16 feet wide with a 1-foot center elevation. A trench is dug 2 feet wide and 15 to 18 inches deep, is filled almost level with well-fermented manure, and a portion of the surface soil is thrown over it, slightly more being drawn in where the plants are to be set. The frames then are set in place and covered with sash, which in turn are further protected with mats and wooden shutters, or hay or straw with or without the shutters. Exposed sides of the frames are banked with warm manure.

When the soil over the manure is well warmed, the warmest portion of some favorable day is selected for planting. Great care is exercised in transferring the plants to guard against setbacks from sudden changes of temperature or disturbance of the roots. The coddling process does not cease now; it simply is spread over a greater area and the plants require even closer care than before. When the runners fairly occupy the inclosed area the frames are raised a few inches. As the season advances more and more air is admitted until, finally, when the melons are almost full grown, the sash and then the frames themselves are removed.

As each fruit sets, its shoot is pinched off one or two joints beyond it. As the melon attains size, it is usually lifted from the soil by a shingle or a flat stone, to avoid loss from cracking, rot, etc. Uniform shape, color, netting, and ripening are secured by turning the fruit every few days.

For shipping to distant markets the melons are packed in excelsior or fine-stemmed hay.

WINTER MELON (*Cucumis Melo* var. *inodorus*)

The best known winter varieties are the *Casaba* or *Go* *Beauty*, and *Honey Dew* melons grown most largely in South California. The fruits are large, the rind is smooth or wrin and hard. They lack the musky odor characteristic of muskmel and keep two or three months under cool, dry conditions. plants must have a very long season, and high temperatures with humidity, to produce satisfactory crops. Other requirements culture are similar to those of the muskmelon.

WATERMELON (*Citrullus vulgaris*)

History and importance.—The watermelon apparently is a tive of Africa. It has been grown in America since early colo times. Although a popular dessert vegetable in many parts of world, it has met with greatest favor in the United States. Ther evidence that melons of this species, perhaps citrons, were fo by early explorers among the Indians in the Mississippi Valley.

The watermelon crop is of great importance in the south states and is shipped in large quantities from Georgia, Te Florida, and the Carolinas. It is of considerable importance in a number of the warmer western and northern states.

Adaptations.—The watermelon thrives best in the South, wh the seasons are long, the day and night temperatures are high, where frost seldom interferes with the progress of the young pla or the ripening of the fruits. The watermelon requires higher te peratures than the muskmelon and most of the varieties requir longer season to mature. While this vegetable demands heat, s shine, and a long summer, it is produced successfully in the No when proper cultural conditions are provided and suitable varie are used. Plants must be started in bands or pots under glass wh the growing season is much less than four months. Light soils preferable and practically a necessity in cool regions.

Culture.—The suggestions that have been made for cucurb as a whole and muskmelons in particular are generally applicable growing watermelons. The watermelon, however, is notably toler of acidity and, under certain conditions, may succeed better af application of acidulating materials such as sulphate of ammon

Where soil is rather poor, watermelons may be planted in hi 8x8 feet apart; but the more common distance is 10x10 feet, wh in rich soils, the hills are often 12x12 feet. Eight or ten seeds planted to the hill, or about a pound to the acre. Several pla are left at the first thinning and no more than one or two at the l thinning. After hard rains the soil should be stirred lightly arou

e young plants, and cultivation should always be shallow. Pruning reduce the number of fruits to the plant to about two often is acticed to secure larger, more uniform watermelons.

Harvesting.—It is exceedingly important that every fruit be nt to market at the proper stage of maturity. Because waterelons keep and carry well when nearly ripe enough for immediate e it is unnecessary to harvest them unripe. Little subsequent imrovement has been found in color, flavor, or sugar content of fruits cked immature.

Although the stage of maturity is not evident from size or ex-rnal color, uniform harvesting is possible with experience and care, nd an occasional check-up by cutting a melon. The manifestations f ripeness vary in degree with varieties and with different conitions.

Generally ripeness is most readily determined by rapping the elons with the knuckles or snapping them with the fingers early the day, or at any time when the fruits are turgid. A more r less sharp or metallic ring indicates immaturity, and a dull or uffled sound signifies ripeness. In a negro ballad the old mammy erated her grandson for stealing a green melon: "Be shore, when ou thumps 'em dey allus soun' 'plunk.'"

In some cases a useful indication of ripeness is withering of the endril at the junction of the fruit stem and vine. Other helpful igns are yellowing and toughening of the soil spot on the underside f the melon.

In gathering for immediate use, ripeness may be determined by a risp, cracking sound when the melon is pressed with the flat of the and, but this test is damaging to melons for market.

Early morning picking not only facilitates the selection of uniormly ripe fruits but secures the melons at a time when they conin the most water and the flesh will remain crisp for the longest me.

The stems are usually cut about 2 inches long. If green they ay be disinfected to control stem-end rot in transit or storage. t the time of treating the end is clipped to expose a fresh surface hich is covered with a paste of 2 ounces of starch and 2 ounces of opper sulphate in a quart of water.

Transportation.—Watermelons generally are shipped in bulk, ithout refrigeration, in box or cattle cars. They are piled in egular tiers, usually 4 deep of the larger sizes and 5 of the smaller. he number to a carload ranges from 700 or 800 large 35-pound elons to 1,500 approximately 18-pound size. A foot of straw hould be placed in wagons, trucks, or cars before loading melons.

Varieties.—Watermelon varieties present great differences in arliness, size, form, shade of green or character of markings, depth

of flesh color, color of seeds, table quality, and shipping quality. Success of the enterprise is dependent in the beginning upon selection of a variety suitable for the conditions. Most markets prefer medium to large fruits of solid green rather than mottled or striped exterior, and with deep red flesh.

Fordhook is early, round, and popular in northern districts where climatic conditions are comparatively unfavorable. *Honey Cream* is a promising newer variety for the North. It is about as early as the Bender muskmelon, yellow-fleshed, and high in quality. *Early Kansas* and *Early Nebraska* warrant trial where the season is too short for the standard commercial varieties.

Associated Seed Growers, Inc.

FIG. 135.—Dixie Queen, a popular watermelon of midseason maturity.

Kleckley Sweet or *Monte Cristo*, *Halbert Honey*, and *Wondermelon* are second early or main crop melons of excellent quality and well deserved popularity among growers who can truck the crop to market. The fruits are large and oblong but the rind is tender and thin and is not adapted for long distance shipping.

Tom Watson, large and cylindrical, and *Stone Mountain*, nearly round with blunt ends, are outstanding main crop shipping melons. *Klondike*, especially popular in California also is planted in the East. *Dixie Queen*, sometimes called *Cuban Queen*, is gaining favor as a midseason shipping melon.

The *Citron* or *Preserving* melon resembles the watermelon with which it crosses readily. The small, round, or oval fruits are characterized by firm, white flesh which is unpalatable unless cooked.

PUMPKIN AND SQUASH

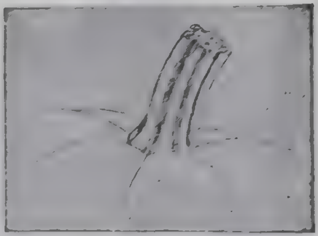
(*Cucurbita pepo, C. moschata, and C. maxima*)

History.—The cultivated *Cucurbits* are undoubtedly of American origin. The earliest explorers found the Indians growing various pumpkins and squashes in such widely separated regions as Florida, Virginia, New England, the St. Lawrence Valley, the Dakotas, the Southwest, Central America, and Peru. Seeds have been found in ancient tombs and burial bowls, the flower is the Hopi Indian emblem of fertility, and the squash appeared in the religious expressions of certain tribes. Pumpkins and squashes are known to have been important food crops of the Indians. In fact, the common names, *squash* and *cushaw*, are derivatives of Indian words.

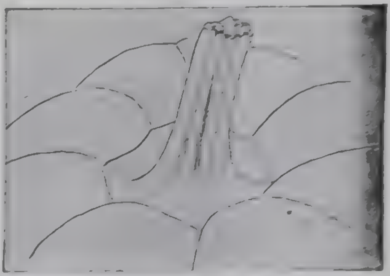
Importance.—These vegetables are not of major rank, yet they are of considerable importance. The true squashes are several times as important as pumpkins, finer grained, and of generally higher quality. Squashes and certain sweet pumpkins are grown very commonly for local demand and, in some localities, for canning. The so-called summer squashes, botanically pumpkins, for use when young and tender, are widely planted in limited amount for local use and for early shipment.

Classification and varieties.—Indiscriminate popular applications of the terms squash and pumpkin, and the general similarity of the plants and the fruits, are confusing. The descriptive terms used here are from Iowa Agricultural Experiment Station Bulletins 244 and 263 by Castetter and Erwin.

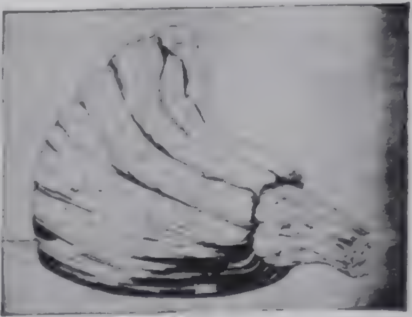
Cucurbita pepo, to which species belong the summer squashes, marrows, and common pumpkins, is denoted by hard, distinctly five-



Fruit stalk of *Cucurbita pepo*, distinctly five-sided and grooved.



Fruit stalk with flaring base characteristic of *Cucurbita moschata*. In certain varieties of *moschata* this is not so pronounced.

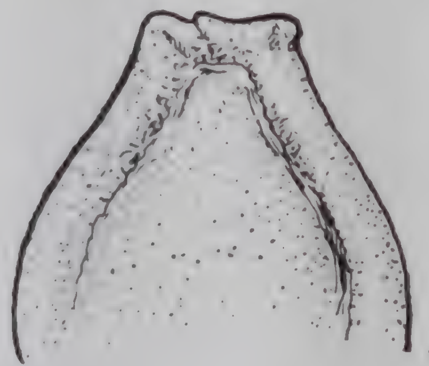


Type of fruit stalk characteristic of *Cucurbita maxima*. Note the cylindrical outline and indistinct grooves.

FIG. 136.—Typical fruit stalks of the cultivated Cucurbita.

sided, regularly grooved fruit stalks, not noticeably flaring or enlarged at attachment to fruit. Popular summer, bush-type varieties of this species are *White Scallop* or *Patty Pan, Early Prolific Straightneck, Golden Summer Straightneck, Cocozelle, Zucchini,* and *Italian Vegetable Marrow.* Leading autumn or winter pumpkins are *Winter Luxury, Small Sugar* or *New England Pie, Table Queen* or *Des Moines* (called squash), and *Connecticut Field,* all of which are of trailing or vining habit.

FIG. 137.—Typical leaf of *Cucurbita pepo,* showing the deeply cut notches characteristic of this species.



C. pepo

Typical seed scar of *C. pepo.* In some varieties the scar is rounded instead of square.

(Illustrations and titles for this Fig. and Nos. 136, 138 and 139 are from Bulletins Nos. 244 and 263, Iowa Agricultural Experiment Station.)

Cucurbita moschata is the least important of the three species. It is most familiarly represented by the *Cushaw* or winter crookneck varieties, and *Large Cheese, Japanese Pie, Tennessee Sweet Potato,* and *Kentucky Field.* The fruit stalks are hard, may be either as described for *C. pepo* but flaring at attachment to fruit, or may be roughly cylindrical, not definitely five-sided, irregularly grooved, not flaring or noticeably enlarged at attachment to fruit. The vining habit prevails.

Cucurbita maxima comprises the true squashes of long keeping qualities and thick, rich, fine-textured flesh. It is easily recognized by the soft and spongy fruit stalks which yield readily to the thumbnail, in contrast with the hard, woody, unyielding fruit stalks of mature pumpkins.

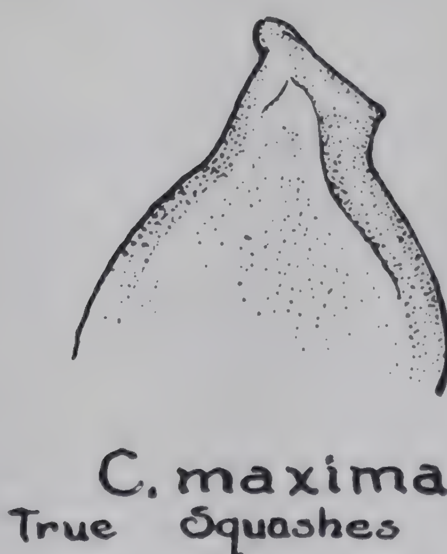
Varieties of *C. maxima* generally are listed by seedsmen as autumn and winter squashes. They are vining in habit. Those of the Hubbard group are most widely planted, high in quality, and

the best keepers. Popular varieties in different localities are *Green Hubbard, Blue Hubbard, Warted Hubbard,* and *Golden Hubbard. Delicious* and *Golden Delicious* are slightly earlier and smaller and of very high quality. *Boston Marrow* is the earliest of the large-fruited squash, bright orange-red in color, very prolific, extensively planted for canning and fall market, but inferior to most other varieties in quality and thickness of flesh. *Warren* or *Essex Hybrid* is an orange-red, turban-shaped variety which is most popular in New England. *Mammoth Chili,* the giant among squashes, often

FIG. 138.—Typical leaf of *C. moschata.*

Characteristic wavy margin and seed scar of *C. moschata.*

FIG. 139.—Typical kidney-shaped leaf of *C. maxima.*



Typical slanting seed scar of *C. maxima.*

weighing 100 pounds or more, with somewhat coarse and stringy flesh, is grown principally for exhibition.

Crossing of Cucurbits.—The question, "Do pumpkins and squashes mix?," is often debated and variously answered partly on account of uncertain application of the common names. The work of several investigators indicates that crossing readily occurs between the two branches of the pumpkin family, *C. pepo* and *C. moschata;* is possible between pumpkins of the species *C. moschata* and the true squashes *C. maxima*, but impossible or productive of sterile progeny, between *C. pepo* and *C. maxima*. In this characteristic, as well as some others, *C. moschata* appears intermediate between *C. pepo* and *C. maxima* (See also page 466).

Joseph Harris Co., Inc.

FIG. 140.—Popular varieties of squashes: 1. Blue Hubbard, 2. Quality, 3. Warted Hubbard, 4. Boston Marrow, 5. Warren (Improved Essex Hybrid), 6. Table Queen, 7. Delicious, 8. Golden Delicious, and 9. Hubbard. All belong to the species *Cucurbita maxima* except Table Queen which is a pumpkin of the species *C. pepo*.

Culture.—The requirements of pumpkins and squashes are not radically different from other cucurbits. The plants are not nearly as tender as the melons, succeed in cooler climates, and will stand somewhat more cold than cucumbers. Nevertheless, they are easily injured by frost, so that planting should not occur until the ground is warm. A rich, warm, well-drained but moist soil is essential to quick maturity and high yields. Plants of the summer bush varieties sometimes are started under glass as are cucumbers and muskmelons (p. 445).

When planted in the open it is customary to sow about 10 seeds to each hill, which is enriched with two or three forkfuls of rotten manure, and then thin to two plants. Summer squashes are often planted in drills and thinned according to the space needs of the variety grown. The bush types of Patty Pan and Crookneck are generally spaced 4x4 or 4x5 feet apart. The vining or running types

need from 8x8 to 10x12 feet, depending upon the fertility of the soil and the vigor of the varieties.

Harvesting and marketing.—Summer squashes must be gathered when the rinds are very tender, and, in many markets, are wanted very young and small. Harvesting of autumn and winter squashes and pumpkins may begin as soon as satisfactory size and color are attained, but development of the best table quality and keeping ability requires nearly full maturity. Careful handling is necessary to prevent unsightly bruising and subsequent early decay. Growers who specialize in winter squashes often store them so successfully that selling may continue for many months after harvest. Single specimens often are kept a year or longer.

Robson Seed Farms

FIG. 141.—Blue Hubbard, an excellent variety of squash.

Ordinary yields are 5 to 10 tons an acre.

Storage.—The storage requirements of squash are practically the same as of sweet potatoes (p. 425). Heavy spoilage usually occurs, however, even in well-insulated and properly heated houses, unless certain precautionary measures are taken.

Black Rot (caused by *Mycosphaerella citrullina*) which is common to the cucurbits, is a primary factor in storage losses of squash. It is combated, according to Massachusetts recommendations, by saving seed from healthy fruits, by seed treatment (described under Diseases of Cucurbits), by 3 year or longer rotations, by disinfection of all surfaces in the storage room with a solution of 1 gallon formaldehyde (40 per cent) in 50 gallons of water, or one pound of copper sulphate in 10 gallons of water if the storage is in an occupied dwelling or barn, and by disinfecting each squash by dipping for a moment in the 1-50 formaldenhyde solution.

Other important factors are: full maturity of fruits, harvesting before frost injury occurs, removal of the fruits with the fruit stalk

attached, use of padded vehicles, and extreme care to avoid scratching or bruising, prompt storing, preferably without intermediate piling in the field, and careful attention to storage conditions. Free ventilation is necessary to dry disinfected fruit promptly and to prevent sweating. Temperatures between 50 and 55 degrees F. generally are recommended. Excellent results have been secured, however, and with less shrinkage, at about 40 to 45 degrees and with humidity below 70 per cent. It is customary to place the individual fruits on racks, or to pile them not more than two or three deep, in ventilated bins.

SEED OF THE CUCURBITS

The cucurbitous crops are well adapted to home-saving of seed. Many growers who specialize in these crops have selected superior strains from which they save seed annually, or perhaps only every other year because high vitality is retained from three to five years.

The majority of gardeners, however, prefer to purchase from dependable sources. Seed cost is low, even with the finest stocks, because only about two pounds of most kinds is required to plant an acre. In any event, well-bred seed must be used to secure large yields of uniform, fancy fruits.

Crossing among the Cucurbitaceae.—The question of crossing or mixing of kinds immediately arises when seed is to be saved, either from market fields or from special seed plats.

Briefly stated: cucumbers cross with cucumbers; muskmelons with muskmelons, cantaloupes and winter melons; and watermelons with watermelons and citrons. Crossing among pumpkins and squashes has been discussed. Crossing does not occur, however, between the different groups represented by the cucumbers, the muskmelons, the pumpkins and squashes, and the watermelons.

The manner of pollination, almost solely by pollen carried on the legs of bees, exposes every unprotected pistillate flower to the possibility of being fertilized by pollen from other varieties that may be growing nearby. At least 40 rods, according to authorities, should intervene between the seed field and other cucurbits of the same species.

Improvement and breeding.—Varieties of any plants that are extensively cross-pollinated are likely to become badly mixed, and often are contaminated with inferior strains or with one unsuited to the particular purpose of the planting. Material improvement sometimes may follow careful mass selection for the desired type.

A more ambitious program is to make selections, test the progenies, and increase the remnant seed of one or more outstanding selections, in the general manner described for corn (p. 435). The

effort will be more effective as a rule, however, if the selected fruits are derived from self-pollinated flowers. Subsequently, self-pollination must be continued for about three generations to fix the type of any line that may be worth retaining. Then, if necessary, vigor may be increased by crossing desirable lines.

There are many variations from the procedure mentioned, but essentially they all begin with self-pollinating so that the true genetic character, including recessive factors, may be disclosed. Then the most promising lines are selected, fixed by sufficient continuance of inbreeding, and perhaps recombined as previously mentioned.

In seeking new varieties the starting point may be the crossing of promising parents, each of which it is hoped will contribute certain desired qualities, followed by selection and inbreeding of the best lines.

The step-by-step suggestions that follow are included for the use of specialized commercial growers, or "hobby" gardeners, who may wish to undertake crossing and improvement. They are by Tiedjens in issue No. 93 of the Journal of the Market Garden Field Station, Massachusetts State College:

"1. Select out the plants having the fruit and plant characteristics that come close to your ideal.

"2. Pick off all cucumbers and female flowers which have opened.

"3. Get some small paper sacks or fold up some soft paper and tie it over the female flowers (and a few male flowers), before they are open or when they are beginning to show a little yellow, on the plants you select as your parents. This can best be done in the evening, because you can tell which flowers will open the next morning.

"4. Look at these covered female flowers early the next morning before the bees start to work and if the flower is open get a male flower from one of the other selected plants and gently rub the male flower on the pistil or central part of the female flower. That cross pollinates the seed. If you want to self-pollinate take the male flower from the same plant on which your female flower is located.

"5. Cover the female flowers again after pollination and after three days take off the paper bags and mark the small pickle so that it will remain on the vine until it starts to turn yellow.

"For those who want to go into the breeding of cucumbers the same method is followed as above but in addition the following points must be followed.

"6. Keep the seed from the ripe cucumber separate and plant it.

"7. When the plants are throwing female flowers, self-pollinate the female flowers and again save the seed.

"8. Plant this seed, which will give many different kinds of plants, and select out the desirable kinds that show considerable vigor. The weak ones should be thrown away.

"9. Self-pollinate the female flowers on the selected plants and if the seed from these gives plants which are uniform for shape of fruit of the type you want, hand pollinate quite a number of these female flowers with male flowers from either the same plant or another plant just like it. The seed from these ripe cucumbers is your commercial variety and in order to save seed from it from year to year follow the first four steps.

"Always remember to keep the female flowers covered so bees cannot get t them and do the pollinating early in the morning before the bees are workin This method will work for all the other vine crops such as squash, melons, o pumpkins."

Seed separation is accomplished without special equipment by fermentation and subsequent flotation in water as described unde Harvesting, Cleaning, and Curing, Chapter III.

Commercial seed production.—Experienced plant breeder develop and maintain carefully bred lines from which foundatio stock and finally commercial seed is produced. The last increas usually is accomplished by contract growers to whom stock seed i furnished by the seedsman. In the latter stages no actual improve ment or breeding is undertaken, but careful rogueing is employed t maintain purity of type.

The states of Colorado, California, Michigan, Nebraska, an New York are important producers of seed of the cucurbits.

INSECTS AND DISEASES OF THE CUCURBITS

With the cucurbits, unfailing and thorough application of th best available measures generally is necessary to produce a larg crop. Neglect frequently entails severe losses, because many of th enemies of these crops attack with great rapidity, and the plant of several kinds are inclined to succumb easily.

The cucurbitous crops, with some exceptions, are attacked b the same insects and diseases. In many instances different enemie may be controlled by the same measure. Hence, it is not inappro priate to emphasize the control program as a whole, and to trea as briefly as possible, the several causal agents.

INSECTS ATTACKING THE CUCURBITS

Striped cucumber beetle (*Diabrotica vittata*).—This stripe yellow and black insect is too familiar to require description. It very destructive, in fact, the most serious insect enemy of the cucu bits. The adults hibernate beneath trash or other shelter and emerg early in the spring. They feed for a time on various plants bu concentrate on the first cucurbits they can find. Egg laying begin promptly. When the beetles are numerous they may destroy u protected young plants in a single day.

Although feeding occurs at all stages of growth, the most seve damage is sustained in three connections. First, the adults, whic are practically omnipresent and exceedingly voracious, attack th emerging seedlings. They even enter into soil crevices and gna holes in the stems. Second, larvae hatch in about a week and ofte

burrow in great numbers into the underground stems and the stems where they touch the ground, weakening and sometimes killing the plants. Third, cucumber beetles are the principal agents of transmission of bacterial wilt and mosaic, both serious diseases against which there is no effectual control after infection.

Control during the early stages of growth is accomplished most conveniently and effectively by dusting with a mixture of one pound calcium arsenate with 15 or 20 pounds of finely powdered gypsum. This usually is available in the form of high grade molding plaster from dealers in building supplies. If gypsum is unavailable, the most finely pulverized agricultural limestone may be used as a substitute. Cheap flour is an excellent diluent and sticks well. Hydrated or air-slaked lime, although often used, causes more or less stunting of cucurbits. Sulphur may injure the plants.

Because many of the beetles are not killed but merely repelled, treatment of the whole field should be completed the same day, and adjoining fields should be dusted at the same time. Otherwise the insects may migrate en masse to the unprotected areas and destroy the plants before the attack is discovered. Frequency of application may vary with rainfall, rate of growth, prevalence, and activity of the beetles. They are much more destructive on hot days.

The most efficient means of actually killing the beetles is to apply 4 per cent nicotine dust with the assistance of a hood or cone. See the topics Nicotine and Dust Nozzles and Hoods, Chapter X. Rotenone dusts which do not contain sulphur also are effective, but the calcium arsenate-gypsum formula is less expensive than the others and is very satisfactory.

At first a hand-duster is convenient and saves material. After the vines begin to spread, a row-crop duster or sprayer is preferable. Spray and dust formulae are suggested under *Angular leaf-spot*. Wire screen protectors are sometimes used by home gardeners.

Twelve-spotted cucumber beetle *(Diabrotica duodecim punctata)*.—This insect is closely related to the striped cucumber beetle and the same control measures apply. It usually is not numerous early in the season, however, and is destructive principally as a carrier of disease.

Aphis *(Aphis gossypii)*.—The variously called melon aphis, cucumber aphis, and greenhouse black-fly is the species of plant louse that most commonly attacks cucurbits. Severe infestations usually develop rather late in the season. Aphids often seriously curtail the length of bearing season and impair the form and quality of the fruits. When the insects are very numerous the leaves curl, turn brown, and die. Control is effected by the use of nicotine preparations as previously described. Dusts containing 3 or 4 per cent nicotine are preferable to sprays.

Pickle worm and melon worm (*Diaphania nitidalia* and *D. hyalinata*).—In late spring the adult moths deposit eggs on all parts of the plants including the blossoms. Many of the larvae enter the fruits and usually cause decay in a short time. The best method of control is to plant summer squashes (bush pumpkins), which the insects prefer, as trap plants at intervals in the field. Later these and their insect inhabitants are destroyed by spraying with kerosene. Where the injury is greatest, particularly in the South, it may be necessary to make one or more succession plantings of the trap crop to assure a continuous supply of blossoms to lure the adults.

Spraying is ineffective as a direct means of control, but the future population of adults may be limited to some degree by applying arsenicals to kill the larvae feeding on the foliage and by prompt disposal of infested crop residues.

Squash bug (*Anasa tristis*).—This insect is the familiar gray to brown "squash stink bug," usually seen in colonies on the underside of the leaves. It is seldom destructive in large commercial plantings but may be a serious problem in small gardens. Common control measures are: killing of adults which congregate in the fall on tender fruits remaining in the field; clean farming to eliminate hibernating places in crop refuse or trashy borders, and trapping the insects under small boards placed around infested plants, where the pests will be found in early morning. The immature forms may be killed by applications of nicotine or pyrethrum. Certain commercial combinations of these materials are effective.

Squash vine-borer (*Melittia satyriniformis*).—The brown-headed white larvae burrow longitudinally within the stems, and sometimes the petioles and fruit. This direct injury and often incidental decay will check growth or kill the vine. Rotation, prompt burning or composting of the vines after harvest, fall harrowing to expose the cocoons, clean plowing, and liberal fertilization are very helpful. Trap plants of summer squash planted slightly earlier than the main crop will divert a large proportion of the eggs.

On a small planting, the affected vines may be slit longitudinally with a knife and the borers removed. Immediate covering with earth promotes healing.

A common practice is to mound earth over each stem, 2 or 3 feet from the base, to induce the formation of supplementary root systems that will support the vine if the basal portion is killed.

Three or four applications of either strong nicotine-soap solution, containing one pint of 40 per cent nicotine sulphate and about 10 ounces of soap to 10 gallons of water, or of rotenone dust, preferably one per cent strength, have been quite effective, but are rather expensive. These materials should be applied to the basal portions

of the stems at weekly intervals, beginning when the singly deposited, reddish-brown eggs are found.

DISEASES ATTACKING THE CUCURBITS

Bacterial wilt (caused by *Bacillus tracheiphilus*).—This disease often is troublesome. First a single leaf wilts and dies. Soon the whole plant is affected and dies or is dwarfed. The bacteria inhabit the fibro-vascular system or conducting tubes. Hence, it is useless to spray an infected plant, and of little value to spray healthy ones except to combat other diseases and the beetles.

The organism is carried over winter in the digestive tracts of the cucumber beetles. Droppings fall on the leaves and the bacteria enter. Further dissemination occurs with the activities of insects and workers. Control is effected by fighting the cucumber beetles from the moment the young plants begin to push through the ground. Spread of the disease is retarded by burning or burying the first plants that are discovered to be affected.

Angular leaf-spot (caused by *Bacterium lachrymans*); **Anthracnose** (caused by *Colletotrichum lagenarium*); **Downey mildew** (caused by *Peronoplasmopora cubensis*) (*B. & C.*) *Clint;* **Scab** (caused by *Cladosporium cucumerinum*); **White canker or Grease spot** (caused by *Mycosphaerella citrullina*); **Powdery mildew** (caused by *Erysiphe cichoracearum*); **Leaf spot or rust** (caused by *Macrosporum cucumerinum*).—The diseases named do not attack all the cucurbitous crops, nor are they all present in every locality. They differ considerably in nature of causal organism and in characteristics of the disease. Most of them attack leaves, stems, and fruit, in some cases causing severe losses in transit. They are grouped here because a general program of control can be set up for them, as several representatives are likely to be present anywhere.

With some exceptions, the organisms survive in the soil, are borne on the seed, but succumb to seed treatment as hereinafter described, and are controlled by proper application of bordeaux mixture or other copper fungicides. See control program outlined on the following page.

Mosaic (caused by a virus).—Affected vines are characterized by mottling of the leaves with light yellow areas. The fruits may be mottled or almost white, and often have a much roughened surface. Vigorous efforts are needed to prevent mosaic from accumulating to a disastrous degree in localities where many cucurbits are grown.

The virus survives from year to year in certain perennial weeds, notably milkweed, catnip, pokeweed and ground cherry or husk

tomato. It also overwinters in the seed of wild cucumber. It is transmitted to the cucurbits (except watermelon which is resistant) on the mouth parts of insects; new infections appear in about a week, and further spread occurs with the activities of insects and the operations of cultivating and harvesting.

Control begins by locating the cucumber field at some distance from weedy areas, if possible, and by eradicating the susceptible weeds. Weed eradication is a laborious but necessary task that should begin the year before cucumbers are planted and continue for some time after they are planted. Infected cucumber plants that may appear early in the season should be removed. Thorough control of insects is effective in reducing spread of mosaic. Resistant varieties may be developed.

Fusarium wilt (caused by *Fusarium spp.*).—Fusaria of one or more species attack the cucurbits, particularly watermelons in the South. Infection results in falling of the foliage and frequently kills the vine. In some cases resistant varieties are available. Long rotations, destruction of diseased refuse, use of sterilized soil in plant growing, use of seed from healthy plants, and control of insects are advisable.

Control program.—On account of the important incidental effects of certain measures, for example, the reduction in bacterial wilt through strict control of beetles, a synopsis of the control program as a whole is especially appropriate for the cucurbits.

1. Choose suitable soils and manage fertility to sustain rapid, thrifty development of the crops.
2. Rotate other crops at least 3 or 4 years between cucurbits.
3. Practice sanitation. Plow cleanly, immediately after harvest, or compost or burn diseased crop refuse.
4. Avoid contaminated manure or compost.
5. Destroy all milkweed, catnip, pokeweed, ground cherry, and wild cucumber plants surrounding the field.
6. Treat all seeds by immersing for 5 minutes in a 1-1,000 solution of corrosive sublimate. Wash well, about 15 minutes, in fresh water. Seed may be planted while it is moist, or it may be dried thoroughly and treated with cuprous oxide dust before being planted where "damping off" is troublesome (pp. 22-27).
7. Start control of the cucumber beetle as soon as the plants begin to appear. Keep the leaves fully protected during the earlier stages of growth. See the topic Cucumber beetles for instructions.
8. Inspect the fields weekly, during at least the first month, and remove all mosaic host-weeds and also the apparently infected crop plants.
9. Spray or dust to control anthracnose, scab, leaf spots, and mildew. This often is unnecessary on pumpkins, squashes, and

watermelons. Do not begin with the fungicide until after several applications of the insecticide have been made for the beetles. If fungicides are applied earlier, the young plants may be very tender and too susceptible to injury. Repeat at about weekly intervals until picking begins and continue longer if necessary. Use 3-3-50 bordeaux mixture on cucumbers, and 2-2-50 on muskmelons. The formula 2-2-50 is preferred by some growers. Include 2 pounds of calcium arsenate to combat beetles. Copper-arsenate-lime dust, preferably 15-15-70, is about equally effective, when thoroughly applied to reach all parts of the plants while they are wet with dew.

It must be noted that cucumbers and muskmelons are unusually susceptible to injury by bordeaux mixture. The recommended formulae are less concentrated than for the tolerant plants, such as potatoes and celery, and the mixture should be prepared with exactitude. The new copper compounds (p. 171) are useful substitutes for bordeaux mixture, particularly in regions of low humidity, where the effects of the latter material in increasing the rate of transpiration may be especially detrimental and diseases are not generally severe. An excellent dust is prepared by mixing:

1 ℔ Cuprous oxide or Copper oxychloride
8 ℔ Flour (or half flour and half talc)
1 ℔ Calcium arsenate.

XXIV

OKRA, MARTYNIA, AND HERBS

OKRA or GUMBO *(Hibiscus esculentus)*

OKRA probably was brought to America along with slaves from Africa. It has been grown in the Mediterranean regions for many centuries. The plant belongs to the *Malvaceae* and is closely related to cotton.

It is a tender annual that requires a long, warm season for its best development. The crop is grown to a considerable extent in the South, and in a limited way in the North. The young, tender pods are used mainly in soups and stews, although they are excellent when boiled and served hot or cold as a salad.

Culture.—The soil should be light and fertile. Planting must await settled warm weather as the seeds require unusually high temperatures for vigorous germination. In the North the plants sometimes are started under glass in pots or bands, so that the shift to the field may be made without disturbing the roots. The planting distances depend upon the vigor of the varieties, but, ordinarily, 1 or 2 by 3 feet apart provide sufficient space. *Long Green* is the most popular variety.

The tender young pods are gathered when they are about one-half grown. Picking may be necessary every day or two when development is rapid. Unless the pods are harvested promptly they become woody and the plant matures rapidly and ceases bearing. Otherwise it will continue growing and producing until it is killed by frost.

Large yields, 200 or 300 bushels to the acre, are possible in the South.

MARTYNIA *(Proboscidea louisiana)*

This annual is a native of the southwestern United States. The coarse plants have a spreading habit. The young, tender fruits are used to a very limited extent for pickling.

Culture.—Sowings may be made in the open, but it is much better in the North to start the plants in hotbeds or greenhouses. They are tender to cold and thrive best in warm soils and in sunny exposures. The plants should be set about 3 or 4 feet apart.

HERBS

The term herb as understood by gardeners indicates plants that are used principally for flavoring or for aromatic effect, or, in some instances, for medicinal purposes. Each is noted for its different and characteristic sweet, spicy, or bitter flavor and aroma.

Certain herbs are grown rather extensively in private gardens, several of them are of local market-garden importance, and a few are grown commercially on a large scale. Mint is grown quite extensively for commercial distillation of the oils. Florence fennel is common in the markets under the name anise, and the seeds of some kinds are produced in quantity for bakeries. The minor importance of the herbs as a whole, however, does not warrant detailed discussion. Culture of Florence fennel, however, is described with the salad crops on page 280.

Most of them are easily grown from seed sown thinly in the open after the soil has become warm, and several may be propagated conveniently by stem cuttings, root divisions, or clump divisions as the habit of growth may indicate. In most cases the plants should

Caterpillar Tractor Co.

Fig. 142.—Transplanting mint on a large scale. In a few localities, mint, fennel (sold as anise), dill or other herbs are important crops. Small quantities are grown for nearly all markets.

be spaced 6 to 12 inches apart in rows a foot or more apart. Generally the perennials should be mulched over winter.

In the list that follows† those marked with a ★ are perennial, and when once established, may be preserved for years. Of these, sow the seed very carefully in seed-beds about the middle of spring, and the following autumn or spring transplant to convenient situations. The others are annuals.

Anise—55 Days
Root and leaf somewhat like celery. 14 to 16 inches tall. Used for garnishing, seasoning and cordials.

★Balm—55 Days
Lemon flavored leaves used in seasoning liquors, etc.

Borage—60 Days
Flowers excellent for bees, and for garnishing cool drinks. Leaves used in salads. Flowers blue, star shaped. Flavor is like cucumber. Foliage very fuzzy.

Caraway—60 Days
Cultivated for seeds which are used in seasoning confectionery, pastry and meat. Foliage like carrot.

Chervil, Curled—60 Days
Divided light green leaves. Used in seasoning salads.

Coriander—50 Days
24 inches. Seeds used for seasoning.

Dill, Mammoth—70 Days
24 inches. Seeds very flat, used in flavoring pickles and preserves. Foliage small and feathery, and flowers attractive yellow.

Fennel Florence—60 Days
Bulb is usually boiled and used in fish sauces. The stalks when blanched often eaten like celery. (See page 280).

★Fennel Sweet—60 Days
24 inches, thick-set plant. Leaves large and finely cut, almost forming a head with wide, straight interior. Foliage resembling Dill.

Horehound—55 Days
Leaves used in flavoring and in cough remedies.

★Lavender—60 Days
Seed germinates very slowly. Flowers used for scenting clothes, and for manufacturing perfume.

★Mint, Old Fashioned—70 Days
For making mint sauce and juleps. Spreads rapidly by means of underground shoots.

Pennyroyal—65 Days
Leaves are used for seasoning puddings. Low growing plant with bluish-lilac flowers.

★Rosemary—70 Days
Foliage dark and shining. Flowers light blue. Used in seasoning and for aromatic oil.

★Sage—70 Days
Long gray-silver leaves produced in profusion, used for seasoning stuffings. Plant 12 inches tall.

★Sorrel—70 Days
Can be eaten raw for salad, or boiled like spinach.

Summer Savory—60 Days
Small purple flowers, used for coloring and flavoring.

† Prepared by D. Landreth Seed Company.

Sweet Basil—60 Days

Tall, light green. Very aromatic. Used for seasoning. Very productive in foliage. 18 inches.

Sweet Marjoram—70 Days

Small mouse-eared foliage used for seasoning. 18 inches.

★Tarragon—65 Days

The leaves, dried or fresh, are steeped in vinegar, which adds a much desired flavor.

★Thyme, Engish—70 Days

Used for seasoning and for making tea for nervous headaches. Small dark-green wiry foliage.

★Thyme, French—70 Days

Common or Narrow Leaf Thyme. Leaves and young shoots used for seasoning.

Waldmeister (Asperula odorata)—70 Days

Used for scenting clothes and flavoring purposes.

★Wormwood—70 Days

For flavoring, medicine and liquors.

XXV

VEGETABLE FORCING

VEGETABLE forcing is the production of vegetables in greenhouses, hotbeds, coldframes, or other structures. In frame culture in the spring or fall, glass may be used during only a part of the period of growth.

The business of vegetable forcing is highly specialized. The purpose of this discussion is to present briefly the fundamental principles and practices.

Competition is severe and is augmented by the improved methods of packing and transportation which supply fresh vegetables from warmer regions throughout the winter season. Under the conditions few growers consider it profitable to expand their glass beyond the area needed for plant growing.

Forcing boxes are the simplest means of advancing the growth of crops. In effect they are miniature coldframes which are placed over certain crops, for example hills of melons or cucumbers, immediately after sowing seeds or setting plants. They are especially useful in regions where the transition period from cool to warm weather is long, and where the summers are too short to produce satisfactory crops of warm-season vegetables. They are used to a limited extent also to advance the harvest in warmer regions. A very few growers use forcing boxes extensively. They usually are made as rectangular, bottomless, light wooden boxes to be covered with a single pane of 10x12-inch glass which slides in grooves to permit ventilation. The use of forcing boxes is described on page 454.

Plant protectors.—In a sense, the various more or less transparent plant protectors, in the form of cones or domes of paper or similar material, also may be considered as small forcing structures. Their use is similar to that of forcing boxes, although they are much less expensive and not so laborious to apply. They are not generally used in the East, but a few growers who have become skilled in their management find them profitable with extra early crops, especially cucurbits or tomatoes. As the days become warmer, ventilation is provided by slitting the tops.

Frame culture is practiced by many market gardeners, and is extensively carried on around certain shipping points within the belt of mild winter weather from Norfolk, Virginia, southward along

J. W. Davis Co.

FIG. 143.—One of the largest vegetable forcing ranges, heated from a central power plant. Houses in the different groups are 425 to 700 feet long.

the seaboard. Both cloth-covered and sash-covered frames are used. Lettuce is the most popular frame crop and radishes are widely grown, sometimes as an intercrop between hills of cucumbers or plants of the solanaceous crops. Beets, cucumbers, muskmelons, tomatoes, and cauliflower often are planted in frames several weeks before they could be started in the open.

FIG. 144—Removing hotcaps from early lettuce with three plants set under each cover. Caps are used most extensively in starting melons and, to a considerable extent, tomatoes and other tender crops.

Newly made hotbeds, spent hotbeds, or coldframes may be used, depending upon the time of planting, the crop, and available facilities. Parsley and lettuce are favorite frame crops for late fall. Little capital is required to engage in frame culture with a few sash, and the enterprise can be expanded as profits justify. Liberal manuring and fertilization, and thorough control of insects and diseases are essential. Frame culture of cucurbits is discussed on page 457.

GREENHOUSE CONSTRUCTION

Greenhouses are in general use among market gardeners. The first house, which perhaps is very small, is built for the purpose of starting early vegetable plants, for which it is found convenient and satisfactory. The owner, however, is often unwilling to have it idle more than half the year; therefore, he tries a forcing crop. If his efforts in the production of crops under glass prove successful, the greenhouse area is increased and new houses are built from

year to year, until the grower is known as a vegetable forcer. Greenhouses furnish better conditions for starting early plants and they may be used 10 or 11 months in the year if the establishment is properly handled. It is not uncommon for market gardeners to operate an acre or more of greenhouse space, while a much larger proportion of growers have from 1,000 to 10,000 square feet of glass.

If forced vegetables can be grown profitably, which is more difficult than formerly when shipping methods and facilities were poorly developed, greenhouses will provide several advantages. With winter crops the grower keeps in touch with the market the whole year round. The houses are ideal for plant growing, and provide pleasant employment in the winter when it often is difficult to find sufficient work to keep men busy.

The size.—The proper size of a greenhouse is determined by a number of factors. It is never safe to build extensively without thorough experience in greenhouse work and marketing. A house 30x100 feet is probably as large as any market gardener should start with, and a smaller structure would be desirable where both capital and experience are limited. A width of 30 feet has been stated, because this is about the minimum width for economical construction, heating, and operation; narrower houses do not provide as uniform atmospheric conditions, and the plants are more likely to be injured by direct cold drafts.

Location and position.—While the natural protection of buildings, trees, or hills on the north and the west sides is highly desirable, greenhouses should not be constructed where they will be shaded.

The position of the house with reference to the points of the compass is not of major importance. With the modern house, ample light will enter with any orientation; most growers, however, have the length of the house running northeast and southwest when it is possible.

Types of construction.—Serviceability, durability, and economical construction and operation are the main points to keep in mind when building greenhouses. Full iron frame construction may or may not be the most economical in the end; the first cost is from one-third to one-half greater than for semi-iron construction, and this additional expense may exceed the cost of repairs in other types. With proper care and painting the wood parts in a well-built house will last 25 years.

Semi-iron type of construction.—This is by far the most popular form of construction. The walls are usually concrete below the side glass and the pipe or angle iron posts which support the roof are placed on concrete footings. If provision is made for walks

or alleys along the walls in the greenhouse the side posts should extend at least 6 feet above the ground level. All purlins, braces, and interior posts are made of iron. Plates, ridges, and rafters are of durable wood, usually cypress. However, angle iron eaves are especially desirable. The construction is of such character that it is easily possible to replace decayed wood parts without disturbing the posts, purlins, or braces. Walks, beds, and benches of concrete may be used if desired. Houses of this type are attractive, serviceable, and durable. Any good carpenter can build them without difficulty, for nearly all wood parts are cut to the right dimensions at the factory and blue prints are furnished for the instruction of builders. Manufacturers of materials supply helpful catalogues and handbooks.

Forms of greenhouses.—Lean-to, even-span, and three-quarter-span are the principal forms of greenhouse construction. The lean-to house is the least expensive type to construct, and it is most useful when erected against a building or wall running northeast and southwest, where there will be practically no shading of the plants. As it is simple in construction, it is popular among home gardeners and small-scale growers.

Even-span houses are the most satisfactory for commercial growers. Sash houses (p. 36) are used to a limited extent in forcing vegetables.

Walls.—Whatever material is used in their construction, the walls should be started below frost line. Concrete walls banked with earth on the outside are warm and inexpensive to construct, and are much better than those built of wooden posts and boards. Although cedar and locust posts last for many years, the lower boards in a wall will soon decay. If the foundation extends about 2 feet above grade level, there will be a height of about 4 feet of glass at the sides between the plate on the concrete wall and the gutter or eaves plate, where sufficient height is desired for a walk next to the wall.

Roof construction.—The size of the roof bars is determined by the width of the glass, and the distances between posts, braces, and purlins and should be short enough that sagging does not occur. An approved method of bracing and standard pitch should be used. In the ridge and furrow plan of construction, gutters must be provided between the houses; these, however, deteriorate quickly unless they are made of rust-resistant metal. Many growers prefer to build with a space of 10 to 15 feet between the houses. This not only renders gutters unnecessary, but reduces shading in the houses and allows room into which snow may slide from the roofs.

Glass.—Experience has taught greenhouse men that anything inferior to A grade double-strength glass should not be used. The

lighter and inferior grades not only sustain greater breakage from hailstones, but the imperfections may cause injury to the plants by burning.

Small glass increases the cost of construction and decreases the amount of light. Glass measuring 16x24 is the standard size today, and is used to a much greater extent than any other size. It is generally laid with the sash bars 16 inches apart. If the panes are graded before glazing so that lights of about equal curvature are placed together, there will be very little space between the laps. A distance of 20 inches between sash bars is regarded as proper by some growers, in which case 20x24-inch glass is used.

Glazing and painting.—A priming coat of paint should be applied to all wood parts before construction is started. The glass then is bedded in a glazing compound or in putty consisting of one part of white lead to five parts of putty. After puttying the shoulders of the sash bars the glass is placed with the curve up, and pressed down firmly, squeezing out the surplus material. This method of glazing is standard because the putty remains in place and keeps out water and cold air and prevents the escape of heat from the house. Glazing points should be inserted at the laps. After the glass has been laid the house should receive two additional coats of paint; it should be repainted every year to insure maximum durability. Later it may be advisable to "bulb" the house with a glazing compound placed in the outside angle between glass and sash bars.

Ventilators.—Provision must be made for ample ventilation. The most approved plan is to have a line of vents on both sides of the ridge. When houses are used until midsummer or later, side ventilators often are provided. It is of the greatest importance that the ventilating machinery work properly.

Beds, benches, and walks.—At one time vegetable forcers thought it essential to provide benches with bottom heat for practically all greenhouse crops, but the opinions held today are different. In many of the largest and most successful vegetable forcing ranges there are no benches or even ground beds with board, brick, or concrete sides. The houses often have large doors at the ends so that a horse and cart can enter with manure or other supplies. It is also possible to use plow and harrow in the preparation of the soil for planting.

Benches are convenient for handling flats and potted plants, but they are expensive to construct and maintain unless made of concrete and they waste space. In some cases they may be needed to supply bottom heat for starting warmth-loving plants.

Solid beds, with or without sides, provide more uniform moisture conditions than do raised benches and there is less danger of injury from improper watering. Solid beds are especially advantageous

when the watering must be intrusted to men of limited experience

The walks should be arranged so that all the beds can be carec for conveniently. Beds or benches 5 to 8 feet wide and walks or alleys 18 inches in width make a desirable combination, although the width of beds in large commercial houses is generally much greater. As plants do not thrive next to the walls, it is desirable to have walks there, and the house space can then be divided in such manner as may seem convenient for the care and harvesting of the crops to be grown.

Steam versus hotwater heating.—Hot water is unquestionably the best system of heating small houses because the pipes retain heat for a greater length of time. Thus the boiler may be left for longer periods without attention, a matter of great advantage in small greenhouses, where it would not pay to employ a night fireman.

On the other hand the steam heating system requires less radiation and is, therefore, less expensive to install. Steam also may be piped with less difficulty to a distance for auxilliary heating of hotbeds or cold frames and is useful for disinfecting soil (p. 44).

The boiler.—The boiler should be of ample capacity to maintain proper temperatures; forcing a boiler means waste of fuel, anc the boiler itself will not last long. The construction should be o such type that the greatest heat will be realized from the fue consumed.

Radiation.—Most frequently 1½ and 2-inch pipe is used fo the coils in hot water heating and 1¼-inch pipe for steam heating connecting with mains of proper size. Whatever the system, th pipe should be placed with the greatest care, observing the prin ciples of the method of heating to be used. Inexperienced builder can secure detailed instructions and plans from the firms supplyin construction materials. Farmers' Bulletin 1218 of the United State Department of Agriculture is useful in planning the system.

The work room.—In every greenhouse establishment there is great deal of work to be done in the way of seed sowing, transplant ing, potting, and preparing crops for market. A convenient, com modious work-room is a necessity. The room should be well lighte and properly heated and ventilated. Tables of the right height ar necessary, and a small room for tools will be found very convenient

GREENHOUSE MANAGEMENT

Because conditions in the greenhouse are artificial, the succes of the crops depends upon skill and regularity of management. Sug gestions in Chapter IV under the topics: Soil supply (p. 43), Soi

disinfection (p. 44), Watering (p. 56), and Ventilation (p. 57) apply equally in general greenhouse management.

Soils.—Naturally deep, well drained, friable soils are desirable, but the original character of the soil in greenhouses is changed so rapidly that the exact type is not particularly important. Both heavy and light soils, as originally found, are common in greenhouses. Because several crops, often lettuce, tomatoes, and cucum-

The E. Bigelow Co.

FIG. 145.—Four-inch drain tile header in place, ready to connect 3-inch drain tile circulating lines joined by tees at the distant ends.

bers, may be grown in the same house in the course of a year or two, the soil should be of generally suitable type.

In small houses it may be most convenient and economical to replace the soil every year or two.

In commercial ranges the soil usually is disinfected as often as necessary and retained indefinitely. The buried tile system of steaming the soil, as illustrated, is employed most extensively. Details of installation and operation can be secured from the Agricultural Experiment Stations of important vegetable forcing states, of which Ohio is first, as well as from certain manufacturers of tile, and well informed growers. Two especially important points are admission of steam to both ends of the header and connection of the distant ends of the lateral lines to assure even distribution and circulation. Disinfection of soil with formaldehyde and small scale use of steam have been considered (p. 44).

Manures and Fertilizers.—Because of the very high overhead costs in vegetable forcing, both manure and fertilizer should be used in optimum amounts. Maintenance of excellent physical condition and light texture requires yearly applications of 25 to 50 tons of manure to the acre—about one ton to a thousand square feet. The usual practice is to apply all the manure before the fall crop and to work it thoroughly and deeply into the soil.

At one time manure was used almost exclusively in the fertilization of crops grown under glass, but it is now recognized that many troubles of greenhouse crops are due to inadequate, often unbalanced, nutrition. The finer points, particularly timely top-dressing of cucumbers and tomatoes with nitrogen or potash, are learned only by study, observation, and experience. Actual practices vary considerably with crops, soils, and methods of the individual grower (pp. 491, 495).

As a general rule, 1000 pounds to the acre, that is 25 pounds to 1000 square feet, of a suitable fertilizer can be applied with advantage before each crop and serve to supplement the application of manure as suggested. Fertilizer applications should be worked into the soil thoroughly and evenly. Concerning analyses, 5-10-5, or 4-12-4 if very much manure has been applied, are often used before lettuce, cucumbers, and fall tomatoes. When tomatoes are planted during the dark months, 0-10-10 or the equivalent is recommended. Top-dressing is discussed in connection with tomatoes and cucumbers (pp. 491, 495).

Lime.—Although it is unwise to permit high acidity to develop in the greenhouse soil, excessive liming should be avoided. Some growers apply 1000 pounds of dolomitic limestone to the acre yearly, a practice which is not likely to lead to difficulties either way. Actual testing for lime requirement is advisable.

Watering.—The principles described for plant growing are fundamental guides, but it should be emphasized that greenhouse vegetables suffer more frequently than is realized from lack of water. Dry subsoil at the time of summer or fall planting is a serious handicap. Long continued watering, preferably before planting, may be required. Again, the fruitful period of spring tomatoes and particularly of cucumbers often is curtailed, and yields are reduced because of inadequate supplies of water. Excessive watering also is very detrimental, especially in late fall and winter.

Temperatures.—Definite temperatures cannot be established as ideal. Slightly higher temperatures may be desirable to establish newly set plants quickly and somewhat lower temperatures than normal may be desirable under some conditions to retard over-vegetative growth. The temperatures indicated below may be considered normal for average conditions. The range given embraces the ideas of different growers and the usually permissible variations.

NORMAL TEMPERATURES IN VEGETABLE FORCING
(In degrees Fahrenheit)

Crop	*Night*	*Cloudy Days*	*Sunny Days*
Lettuce	45-50 (55)	50-55	55-60 (70)
Tomatoes	60-65	65-70	70-80
Cucumbers	65-70	70-75	75-90
Radishes	43-48	50-55	55-65
Rhubarb	50-60	(Usually grown in darkness)	
Mushrooms	50-60	(Higher temperatures are objectionable)	

Day temperatures occasionally 10 to 15 degrees higher than those suggested are not likely to prove detrimental on sunny days with free ventilation and low humidity. Long continued temperatures below normal may cause stunting from which the crop, especially cucumbers, may not fully recover. Too high temperatures are followed by soft, spindly, succulent growth, and in extreme cases by dropping of blossoms and should be avoided if possible.

Mulching with strawy manure is common practice with tomatoes and cucumbers but may reduce yields at seasons when much nitrogen is needed by the growing crop. This objection may be overcome by heavier feeding with nitrogen (p. 75).

Fumigation is the most convenient and effective means of combating most insects that cause injury to greenhouse crops. The first step in fumigating is to calculate the volume of the house. The cross sectional area (the area of an end) in square feet is multiplied by the length in feet; the product is the number of cubic feet of

space in the house which should be determined with accuracy. Broken glass must be replaced and all other openings closed. N applications of water should be made within 24 hours as the plant must be perfectly dry and the humidity low. It is preferable tha the plants grow "on the dry side" for a few days. An even c slightly rising temperature during fumigation will avoid condensa tion. Temperatures of 60 to 70° F. are suggested. Fumigation ma begin an hour or more after sundown. Observance of these pre cautions is necessary to avoid burning the more tender portions c sensitive plants. To avoid wastage of gas select a calm night, bu not a rainy one.

Hydrocyanic acid gas is effective against aphids, white flies and thrips, but it must not be used after applications of bordeau mixture or copper lime dust. These fungicides may be applied afte hydrocyanic fumigation.

The simplest method of fumigating with hydrocyanic acid ga is to scatter calcium cyanide thinly and evenly on the walks. Libera tion of the deadly gas begins immediately. The correct dosag varies from ⅛ to ¼ ounce to 1,000 cubic feet, depending upon con ditions. It is safer to start with the smaller dosage and increase i necessary at the next fumigation. Fumigation every 10 to 14 day will secure effective control.

Because hydrocyanic acid gas is extremely poisonous it shoul never be used to fumigate greenhouses that are connected wit buildings in which human beings or domestic animals are presen during the treatment. Avoid breathing the least trace of either th dust or the fumes. Make certain all people and pets are out c the house before spreading the cyanide, and that the exit is ope If there is more than one walk one person should be assigned to eac All workers should begin at the same time at the end farthest fro the door, proceed quickly at the same rate, and leave the house t gether. Doors should then be closed and locked, and signs poste at all entrances reading "Danger—Fumigating with Poison Gas Never go back over a fumigated area immediately, or reenter th house until the next day. Then open the doors and ventilators air the house.

Empty houses sometimes are fumigated for a period of 24 hou with one or two pounds of calcium cyanide to 1,000 cubic feet "burn out" pests that may be present. Temperatures of 70° or higher are recommended.

Fumigation with nicotine which is effective against aphids convenient and safe but usually more expensive than hydrocyan acid gas. Nicotine usually is employed, however, where aphids a the principal pest. It may be applied in a number of simple way

and manufacturers will supply full information on dosages and procedure.

Fumigation by burning sulphur after the last of the crop has been harvested will kill exposed insects and spores of fungus diseases. Sublimed or refined sulphur burns more readily and is recommended at the rate of 1 pound to 2,000 cubic feet for a 24-hour fumigation. Greater dosages are unnecessary and undesirable, on account of their effect on paint, pipe, and wires.

A sulphur vaporizing machine advertised as the Solfur Nebulator provides a means of mild fumigation that is useful in controlling leaf mold of tomatoes when the treatments are begun in the early stages.

PRINCIPAL FORCING CROPS

Lettuce.—The Grand Rapids variety of leaf lettuce is planted almost exclusively in greenhouses. Butter heading varieties, such as White-seeded Tennisball, May King, and Boston Market or Belmont, are grown to a limited extent, particularly around Boston. Cos or Romaine lettuce is produced for special demand. New York, commercially known as Iceberg, lettuce has not proved profitable on account of the long period of growth and usually excellent condition and low price of the western shipped product.

March Automatic Irrigation Co.

FIG. 146.—Irrigating greenhouse lettuce.

Fertilizers and temperatures (pp. 486, 487) for greenhouse lettuce have been suggested. Spray irrigation is permissible for this crop.

Lettuce plants must be ready to set in the beds at the desired planting dates or valuable time and space will be lost. Seed for the earliest practical fall crop usually is sown in shaded houses or outdoors about the middle of August. The seedlings are transplanted about 2 by 2 inches apart, and are shifted to the beds as soon as they are of desired size. Later sowings will be required to provide plants for resetting the house, and it should be remembered that six weeks

may be required to grow plants of suitable size during the winter months. Popular planting distances are 7 by 7, 7½ by 7½, 8 by 8, 7 by 8, and 7 by 9 inches.

Harvesting leaf lettuce in less than six weeks from setting in the beds is unlikely to be as profitable as when more time is given. After a certain point, increases in weight take place very rapidly. Overmaturity reduces table and market quality, however, and may result in losses to the grower. Harvesting early may be advantageous to make way for a succeeding crop or to sell retail by count. Lettuce diseases were discussed (pp. 275, 276).

Radish.—This crop demands maximum light and will not do well in dark houses at midwinter, or as an intercrop where it is subject to shading. The quickly-growing, short-topped selections of Scarlet Globe usually are grown. High temperatures (p. 487) or crowding will result in excessive development of leaves. Spacing 4 to 5 inches between rows, and sowing or thinning to secure 8 to 10 plants to the foot of row, are standard. Four to 8 weeks, depending upon the amount of sunshine and length of days, are required to mature the crop.

Tomato.—Because this crop requires uniform warmth (p. 487) and is subject to leaf disease its culture during the fall and winter should be undertaken only in first-class houses that are well-lighted, not leaky, and easily heated. The spring crop is less difficult to manage. The long period of growth requires effective control of insects, especially the white fly.

Varieties of the Bonny Best class, including John Baer and Chalk Jewel, are generally popular. Globe is desirable where pink fruits are wanted. Marvel, Break O'Day, Marglobe and Marhio are useful where resistance to wilt is essential. Varieties of English ancestry, such as Comet, Carter Sunrise, and Grand Rapids forcing, produce many-fruited clusters of comparatively small tomatoes and are preferred where the markets readily accept small fruits.

The fall crop yields most heavily when started in time for a number of clusters to be set before dull, winter weather begins. The seed usually is sown late in June or early in July and well grown plants are set in the greenhouse not later than the middle of August.

The midwinter crop is the most difficult to grow and produces disappointing yields without the best management and equipment. Seed for it is sown in August, September, or October, depending on when the plants are to be set in the beds.

Plants for the spring crop usually are set during February which requires the sowing of seed about December 1. The methods of plant growing should be such that sizeable, vigorous plants are produced. Low-grade plants lengthen the unfruitful period. Plants transplanted once into 4-inch pots or bands are ideal (pp. 285, 453).

Popular planting distances are 18 by 36 to 20 by 42 inches. Many growers prefer spacings of 16 to 18 inches, however, in rows about 3½ feet apart, on account of greater convenience in working among the plants and better circulation of air between the rows. Crowding increases the expense of plants, because greater numbers are required, provides more favorable conditions for disease, and is more likely to decrease than to increase the total yield.

As a guiding principle in fertilizing greenhouse tomatoes, and to a certain extent cucumbers, nitrogen should be provided in liberal supply in the spring and during the long sunny days of summer, but it is required in relatively limited amounts during the short, usually dark days of late fall and winter. It is commonly thought that excess nitrogen results in failure to set fruit during prolonged cloudy weather and, under the same conditions, liberal fertilization with potash promotes normal ripening and aids the development of solid, well-filled fruits (p. 100).

Fall tomatoes set in the beds during August may receive about 1000 pounds to the acre, or 25 pounds to 1000 square feet, of 5-10-5 before planting. Two or three weeks later about 5 pounds of nitrate of soda to 1,000 square feet, or the equivalent, can be applied as top-dressing. Additional nitrogenous top-dressings at intervals of about two weeks may or may not be beneficial, but it is customary to make the last one some time before the period of dark weather begins. By that time the plants should be well set with fruits. Thereafter occasional top-dressings with potash, as 4 or 5 pounds of muriate of potash to 1,000 square feet, are in order, at least on some soils.

The spring crop of tomatoes, if it is planted during the dark weather of winter, needs little or no nitrogen in the pre-planting application. Then the analysis 0-10-10 may be used, however, a fertilizer of 1-2-1 or 1-2-2 ratio would be preferable in some instances. When days become longer and sunny, nitrogenous top-dressings may be instituted and are necessary during the bearing season of spring crops to secure highest yields.

The present trend is to fertilize more heavily than formerly. This has resulted in much higher yields and notably better quality of fruit in the later pickings. A synopsis of recent recommendations of the Ohio Agriculture Experiment Station follows:

(1). Apply about 50 tons of manure to the acre in advance of the fall crop.

(2). In preparing the soil for planting (spring crop tomatoes) work in plow-deep 1000 to 1500 pounds of superphosphate and 750 to 1000 pounds of muriate of potash to the acre.

(3). When the first three clusters of blossoms have set and the earliest fruits are half grown, make the first topdressing. Subsequent applications should follow at intervals of 10 to 14 days during the life of the crop. The rate of each is about 250 pounds to the acre.

First application is potassium nitrate.
Then two of calcium nitrate.
One of potassium nitrate.
Two or three of calcium nitrate.
One of potassium nitrate.

Or 100 pounds of potassium nitrate and 200 pounds of calcium nitrate m
be mixed and used at the recommended rate in making each application.

The topdressing material is broadcast between the rows and watered w
thoroughly to dissolve all the fertilizer and carry it deeply into the soil. Th
root injury is avoided.

Nearly all experienced growers train tomato plants to a sing
stem. Beginning as soon as the plants are set, the laterals a
snapped or pinched out at frequent intervals.

One of the most common means of support is twine tied arou
the base of the plants and stretched vertically to wires or rafte
overhead. See Figure 147. Thin stakes are preferred by som
in which case the plants are tied to the supports at several plac
as growth proceeds. Leaf pruning is not generally advisable.

Natural pollination of greenhouse tomatoes often is inadequa
to produce satisfactory yields. Artificial aid to pollination is pra
tically a necessity during the dark days of winter, often doubles t
yield, and produces smoother fruits. Recommendations from Bu
letin 470 of the Cornell Agricultural Experiment Station, Ithac
N. Y., follow:

"It is recommended that greenhouse growers of American tomato variet
pollinate the flowers on the first three or four clusters by the watch-gl
method in late winter and early spring. Flowers on clusters above the third
the fourth should be pollinated by daily jarring. The emasculation method
just as effective as the watch-glass method, but it is more costly and is less pr
tical with American varieties. With English varieties, however, it is reco
mended for the lower clusters in late winter."

"In the watch-glass method of pollination, a quantity of pollen is collected
a watch glass or a glass slide, from flowers which have expanded petals. T
watch glass is then held in the left hand, being placed just beneath the flow
with well-reflexed petals, and with the right hand the stigma of the flow
is gently brought into contact with the pollen. The pollen might be collec
on the thumb nail or on the tips of the fingers of the left hand, as explain
under the emasculation method, but the watch glass is probably more
sirable. If pollen is applied prematurely, it may lose its vitality before
stigma becomes receptive, and fail to germinate. However, the work of Hart
(1902) indicates that premature pollination does not injure the pistil, so tha
the pistil is again pollinated, when receptive, with fresh pollen it will proba
be fertilized and fruit will develop. An important advantage of the watch-gl
method under commercial conditions is that the supply of pollen on the gl
constantly increases as the work progresses because the pollen may be procu
from blossoms to be pollinated by tapping them before pollinating."

"In pollinating plants by emasculation, the pollen is collected on the thu
nail or on the tips of the first and second fingers of the left hand, from flow
with petals well reflexed. Only flowers which have been fully open and h
closed their petals are pollinated after the petals and stamens have been

ved. As the stamens are attached to the corolla, both may be easily removed one operation by grasping the tip of the wilted corolla with the thumb and first or second finger of the left hand, holding the flower back of the calyx the right hand. Then pollen is applied to the stigma by lightly touching stigmatic surface with either the finger or the thumb nail covered with the en. The thumb and the first finger of the right hand are used to steady the som during the operation. With this method one must be careful, in removthe corolla and the stamens, to pull straight away from the flower, otherwise pistil may be broken at the base of the style. There is also danger of break-

Department of Vegetable Crops, Cornell University

FIG. 147.—Greenhouse tomatoes showing support.

ing the pistil when the finger covered with pollen is brought into contact wi the stigma, because the natural support furnished the pistil by the stamens an the corolla has been removed."

"Jarring the plants is the method which practically all commercial green house men use, chiefly because it is the simplest, easiest, and quickest metho The plant or clusters may be jarred in various ways, but the method employe in these experiments was to grasp the main stem of each individual plant an

Department of Vegetable Crops, Cornell University

FIG. 148.—Tomato fruit cluster showing various stages of flower and fruit development.

a, Petals well reflexed; proper stage for pollination by the watch-glass and brush methods.
b, Flowers have been fully open, and petals have closed and begun to shirvel; proper stage for pollination by the emasculation method.
c, Emasculated flower ready for pollination.
d, Fruit developing from flower pollinated by the emasculation method, showing pistil attached but petals removed.
e, Fruit developing from flower pollinated by the watch-glass method, showing petals attached.
f, Unpollinated flower failing to develop a fruit.

shake it sharply. Jarring was always done toward noon, preferably on sunny days when the temperature was high and the atmosphere dry."

To assure high quality, greenhouse tomatoes should not be harvested until they are well colored. Packages of small size are desirable to prevent bruising and crushing. Paper wrappers and special cartons are used to some extent to protect the fruits and to make attractive packages.

Ten pounds to the plant with spring crops and half this amount, or less, with fall or winter crops are typical yields.

Disease control must not be neglected (pp. 294, 486).

Cucumber.—The first requirement for profitable forcing of cucumbers during cold weather is a house in which uniformly high temperatures can be maintained without prohibitive expense for fuel. Control of insects, nematodes (p. 181), and red spiders (p. 179) must be effective. Red spiders often ruin a crop before their presence is observed.

Popular forcing varieties of cucumbers include Davis Perfect, Abundance, Irondequoit, Deltus, and well-bred selections of White Spine under a variety of names. Many growers develop their own selections and crosses (p. 466).

Strong, vigorous plants that have been grown without checking or stunting are required to produce an early, heavy crop. Plants for the spring crop usually are set in the beds during February, although some growers, especially with poorly heated houses, produce an additional crop of lettuce and defer the bedding of the cucumber crop until March or early April.

Seed should be sown only five or six weeks before the plants are to be ready. Clay pots of veneer bands in 3- to 4-inch sizes generally are used. Several seeds may be sown in each container and the plants thinned to one or two; or the seeds may be sown quite thickly in flats of sand, peat, or light compost. In that case the seedlings must be transplanted to the pots very promptly, usually within a week of sowing (pp. 445, 453).

For the growing of cucumber plants and for the crop, normal night temperatures are 65° to 70° and day temperatures 75° to 90°. The day temperatures may be several degrees lower in cloudy weather and, in early summer, may rise to 100° without harm when ventilation and moisture are not neglected.

As a rule, cucumbers respond favorably to liberal feeding. In addition to the usual application of manure, 1,000 pounds or more to the acre, or 25 pounds to 1,000 square feet, of 5-10-5 or the equivalent may be worked into the soil before planting. Top-dressing after the fruits begin to set is nearly always desirable at intervals of about two weeks, or sooner if the plants begin to turn yellow. When plants of the spring crop are bearing very heavily,

some growers top-dress every week or 10 days. A mixture o pounds of nitrate of soda and 1 pound of muriate of potash to 1 square feet, or an equivalent amount of other fertilizers, may more effective than nitrogen alone. Suggestions for manuring fertilizing tomatoes (pp. 491, 492) are quite applicable.

With the A-trellis the plants usually are spaced 12 to 15 in apart in the rows, with the pairs of rows for a trellis about 5 apart, more or less, so that the trellises suit the width of the be Sufficient space for a narrow walk between trellises ordinari allowed, but not always. In the arbor system the plants are tra on twine or light wooden strips until they reach a flat trellis 7 feet overhead, where they are permitted to spread. Planting tances 3 by 5, 4 by 4, and 4 by 5 are common. The sides of A-trellis and the horizontal overhead trellis usually are constru of No. 16 wires about six inches apart.

In either system the plants are pruned to a single stem and at intervals until they reach the top of the support, where the terminal is pinched out. In the A-system usually the laterals are nipped just beyond the first female blossoms. In the a system a suitable amount of pruning is necessary to prevent dense vining. Although perfect pruning rarely is accompli neglect of the operation is not justifiable as long as the mark satisfactory.

Pollination of the cucumber out-of-doors is accomplishe insects that carry pollen from the male to the female flowers. a few plants, in the amateur's greenhouse, a camel's hair brush be used to transfer pollen from the male flowers to the fe flowers, the ones with miniature cucumbers in the centers.

Bees are used in commercial houses, ordinarily one or two h for houses 200 feet in length. In cold weather the hive mus kept inside and should be shaded. When warm weather ar it is customary to place the hives just outside the houses and move adjacent panes of glass for the bees to enter. Becaus cumber blossoms produce much pollen but little nectar, su mentary feeding of the bees is desirable and the colonies sh be replaced before they become exhausted.

Cucumbers in the greenhouse should be picked three tim week to secure the fruits at the best marketable stage. Ca grading usually increases returns.

Rhubarb is the most easily grown of the forcing crops. produced in cellars of dwellings, beneath greenhouse benches, a special forcing houses constructed of any convenient ma Strong root-clumps, one-year old or older, are lifted with as injury as possible to the large storage roots. After lifting, the must be subjected to thorough but not extremely severe fre

...ual rest period should be at least six or eight weeks. The ...may be stored in any shed or may be sheltered outdoors to ...t them from drying winds, or they may be placed in position ...forcing house if they can be permitted to freeze and rest there ...the heat is turned on.

...e clumps are packed close together when being placed. Light ...coal ashes is worked into all the spaces. The roots should ...n a bed of soil and be covered to a depth of 2 or 3 inches. ...ering will be difficult if the beds are more than 4 or 5 feet ... Very thorough watering is the next step, and additional water ...l be applied as required to maintain moisture. Temperatures ...° to 60° F. are ideal.

...her vegetables are forced in greenhouses to a very limited ex... Although many may be grown successfully, their culture gen... is unprofitable. Forcing of Witloof chicory or French endive ...ussed on page 278.

...ushroom culture.—Successful production of any crop de... upon correct management of many details. This is especially ...n the culture of mushrooms. Extensive production should not ...tempted without experience. Authoritative literature is avail... and should be studied by those who are especially interested. ...ultural directions which follow are only elementary.

...of cellars, the space beneath benches in cool-crop greenhouses, ...d buildings, caves, or mines, can be adapted without much ex... to small-scale growing of mushrooms. The commercial crop ...duced almost entirely in specially constructed houses. The ...mportant characteristic of a suitable place for growing mush... is relatively constant temperature averaging about 55° F. ...he first few weeks after the beds have been planted with ...n the temperature may be maintained at about 70° F. This ... rapid development of the mycelium without injury. After ...sing soil has been added the temperature should be reduced ...° F. or lower. Temperatures below 55° F. are not injurious ...sult in slower growth. After the mushrooms have begun to ...r, temperatures above 60° F. should be avoided as they allow ...velopment of diseases and insect pests. At 70° F. the mush... on the beds begin to show injury and will soon die if the ...rature remains at or above that point for more than a few ... While the most important characteristic of a suitable place ...ushroom growing is the proper temperature, an adequate ...d of ventilation cannot be neglected. This is necessary to pre... the humidity from becoming too high and to avoid the ac...ation of carbon dioxide which is given off abundantly by the ...g mushrooms and the decaying manure.

...anure for mushroom beds almost invariably is prepared by

processing fresh horse manure from animals that have been fe diet containing grain and bedded with straw. A considerable p portion of straw is desirable.

About 3 or 4 weeks before the beds are to be filled the man is placed in rectangular, flat-topped piles with nearly vertical sid At intervals of about 5 days the pile is turned, and rebuilt as scribed for hotbeds (p. 78). At each forking-over, all lumps must shaken apart, the outside of the old pile placed inside the new o and water added to dry spots. After 3 or 4 turnings the comp should be uniformly dark brown in color, friable, and free fr unpleasant odors. The straw should be easy to break when bunch is wrung between the hands. It should not, however, h lost its heat. In this condition it is ready to be placed in the be The moisture content at this stage is important. A test for this to squeeze a handful of the composted manure. It is too if drops of water can be squeezed out, but the hand should beco distinctly wet. If the pile is exposed to the weather it is advisa to protect it from heavy rains toward the end of the composti period.

Prolonged composting is very objectionable as the material comes too fine and loses its resilience, resulting in a lumpy c dition after it is placed in the beds. Also the organic matter being continually lost from the pile as carbon dioxide, thus rem ing nutrients valuable to the mushrooms.

In this country flat beds in tiers are almost universally us while in Europe ridged beds are placed directly on the floor. T former are much superior as they are not in contact with the floo the lowest bed is built 6 inches above the floor—and it is possi to provide much more area to the unit of building volume. T manure is placed 5 to 7 inches deep in the beds. The present pract is not to tamp the compost very much, although some growers s press it firmly into the beds. The temperature should rise at fi Commercial growers try to obtain a temperature of at least 120° in the air of their houses and 130° F. in the beds. This is suffici to kill the insects and disease organisms which otherwise wo menace the crop later on. If the type of building is such that t heating is impossible after the beds are made up, the pile of co post should be large enough so that the cold exterior of the p harboring most of the insects can be discarded and only the hot p used. After filling the beds, if the compost is too dry, several v light waterings may be applied.

Spawning must be delayed until the temperature subsides about 70° F. as determined by a thermometer plunged in the be Further delay is disadvantageous. The best spawn can be p cured directly from growers or specialists, who are in the spa

duction business, and should be fresh. Spawn more than a few ks old, as sometimes sold by dealers, may be worthless.

Three kinds of spawn are available. These are: the older type le from manure in bottles, that using tobacco stems as a base, finally that made from grain. A satisfactory crop may be grown any of the three. The manure spawn can be removed only breaking the bottle. It is then broken into pieces about the size walnuts and buried two inches deep in the beds at 10-inch invals. The tobacco stem spawn is crumbled to fine particles, le the grain spawn is already granular. These are planted at ervals in the beds as is the manure spawn. The grain spawn is re vigorous than the others, one bottle being sufficient to plant square feet of bed. In about 10 to 14 days, but no sooner, the s should be cased with one inch of rich, moist, medium loam , the kind that is ideal for plant growing.

Heavy watering is harmful. The rule with mushrooms is to ter lightly and frequently to keep the casing soil moist but not and to avoid water penetrating to the manure beneath. midity should be high enough to prevent rapid drying of the ing soil, but not excessively high.

Light is not injurious, except for the effect of direct sunlight in sing temperatures.

Production usually begins in 5 to 10 weeks after spawning and tinues for 3 to 6 months. Warm weather, where temperatures not be held down, will shorten the productive period.

Daily picking is necessary to secure the mushrooms as they ain the desired size, before the veil joining the stem and the edges he cap has broken. Mushrooms usually are picked by twisting base of the stem. The holes that are made in picking should closed with casing soil.

Mushrooms should be marketed promptly after picking to avoid necessary deterioration. Great care must be used to avoid bruis- and excess handling. Packaging is important for protection of product. In the Middle West pint and quart paper boxes h cellophane tops are finding especial favor, although some nd boxes are used. In the East 1 and 4-quart climax baskets are epted as standard, being packed to hold 1 and 3 pounds of shrooms. For the local market quart berry boxes will be found sfactory.

The following recommendations for the control of mushroom eases, weed fungi, and insects are by W. S. Beach, Bulletin 351 he Pennsylvania Agricultural Experiment Station:

"Mushroom houses can be made sanitary by fumigation with formaldehyde, s. to 1,000 cu. ft., or burning flowers of sulphur, 2 lbs. to 1,000 cu. ft. To re an effective concentration of the fumes requires tight sealing of all cracks

and ventilators, rapid evolution of the fumes, and thorough diffusion. These requirements are more likely to be attained if the fumes are evolved outside the house with an apparatus designed for the purpose and then blown inside near the floor.

"Fumigation needs to be supplemented by drenching floors and spraying doorways and bottom beds with a fungicidal solution, especially if fumes of formaldehyde or sulphur are evolved within the house. One of the following may be used: 4 lbs. of copper sulphate dissolved in 50 gals. of water, 2½ per cent crude carbolic acid, or 16 lbs. of formaldehyde to 50 gals. of water. Spraying all inside surfaces and structures with a fungicidal solution can be substituted for fumigation. These treatments are also suitable for packing sheds.

"Treat adjacent yards, composting ground, and other exterior parts of the plant that may have become infested with fungous spores, using one of the following fungicidal solutions at the rate of at least a quart to the square foot: 8 lbs. of copper sulphate dissolved in 50 gals. of water, 7 ozs. of mercuric chloride dissolved in 50 gals. of water, or 2½ per cent crude carbolic acid.

"Deposits of spent compost or waste mushroom fragments should not be left near a mushroom house, as they are ready sources of disease.

"Before refilling is begun, empty, clean, and disinfect, as far as possible, all houses that may be infested with disease or weed fungi. This is particularly important in a series of adjoining houses.

"A temperature of 130° to 140° F. after filling is necessary to kill any harmful fungi introduced with the compost. Electric fans set horizontally at the top of the center aisle are usually essential to overcome the differences of temperature between top and bottom beds. Avoid unnecessarily high temperatures, above 140° to 150° F.

"Observe sanitary precautions about houses from the time the compost cools for spawning so that the spores of fungi will not be carried to clean beds. Wash contaminated hands and clothes, and disinfect soiled baskets or other utensils. This is important for the exclusion of the *Verticillium* disease (brown spot), *Mycogone* disease (bubbles), bacterial blotch, and white plaster mold.

"Sterilize the soil for casing, or be certain that it is obtained from a field that has not been contaminated with spent mushroom manure, waste, or drainage from houses having disease. While this applies particularly to the *Mycogone* disease, it is also important in preventing the introduction of other diseases or molds.

"Endeavor to maintain the temperature of bearing beds within the range that is optimum for mushrooms, 55° to 58° F. Many diseases and weed molds become serious on account of abnormally high temperatures. Avoid warm season crops unless an efficient cooling and ventilating system is installed.

"Provide efficient ventilation so that excessive humidity and precipitation of moisture in bearing houses may be readily removed or prevented. A desirable humidity is 88 to 90 per cent. Ventilation is most efficient when the outside temperature is below that inside. Surplus moisture upon mushrooms in the pinhead and button stages should dry readily if brown spot and bacterial blotch are to be held in check.

"Watch for the first occasional or local development of brown spot, bubbles, or mildew. Pick all good mushrooms within an area of disease, and remove and destroy all diseased specimens. Spray the diseased area with a dilute bordeaux mixture (1-1-50 or 2-2-50). This will not injure later flushes and will hold the diseases in check. It is possible to follow this same procedure when brown spot is general. It may prove more effective than recasing with fresh soil. Copper-lime dust, containing 10 or 15 per cent monohydrated copper sulphate and no arsenical, may be substituted for bordeaux mixture.

"Control of readily disseminated weed molds, particularly white plaster mold and olive-green *(Chætomium olivaceum)*, depends chiefly on favorable com-

posting of the manure. If the spawn starts and grows well, it will take possession of the compost in spite of considerable contamination by these molds. If the composting is not favorable and the spawn is retarded, the molds are likely to predominate. It is advisable to test the reaction, or pH, of the compost just before the beds are cooled for spawning to see whether the heating has reduced the pH low enough for the spawn to grow readily. The nearer the pH is to neutral (pH 7.0) the more likely it is that the spawn will outgrow the molds.

"Control of heat-resistant weed molds, like truffle, requires a thorough disinfection of the composting ground and other contaminated places. Spray the interior of infested houses with a fungicidal solution.

"Insects are important carriers of fungous spores, hence control of insects is an aid in checking the spread of harmful fungi.

"Filling houses but once a year is a distinct advantage in the control of harmful fungi because the mushroom crop can be grown entirely within a cool season, when temperature and moisture conditions can be easily kept optimum; many fungi, especially *Verticillium* and white plaster mold, disappear largely by drying during the months that the houses are empty; and there is less likelihood that picking will continue in infested houses while other houses are being refilled."

Solution culture of vegetables, using chemical nutrients in water, is attracting widespread popular attention. Several methods have been devised, of which a typical one is to support the plants on litter-covered screens at the top of shallow tanks containing the solution. Formulae for the solutions vary. As growth takes place composition and reaction of the solution change. Tests must be the basis for correction. It may be necessary to modify the solution to meet the differing needs of the plant as growth progresses or as the length of day changes. The services of a trained plant physiologist are essential for consistently successful production of crops in nutrient solutions. At the present stage of development such methods apparently do not provide commercially valuable advantages over culture in soil.

Sand culture of plants before transplanting into the field is discussed on page 58.